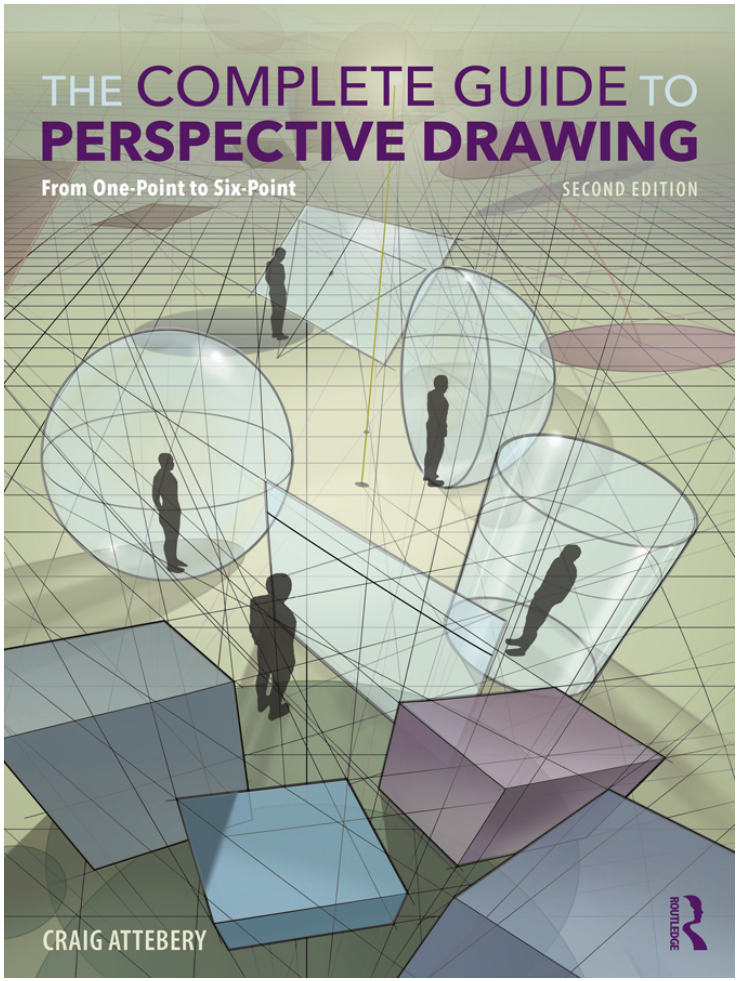
THE COMPLETE GUIDE TO
PERSPECTIVE DRAWING
From One-Point to Six-Point
SECOND EDITION
CRAIG ATTEBERY
ROUTLEDGE

The Complete Guide to Perspective Drawing

As a professional, understanding the foundations of drawing, how we process images, and how we interpret what we see are principal skills. Understanding linear perspective enables artists and architects to accurately communicate their ideas on paper. *The Complete Guide to Perspective Drawing* offers a step-by-step guide for the beginner, as well as the advanced student, on how to draw in one-point through six-point perspective and how to make scientifically accurate conceptual illustrations from simple to complex situations. This new edition has been updated to include:

- Over 30 completed case images showing real applications of the processes and techniques discussed
- Expanded information on ellipses
- Expanded information on three-point perspective shadows
- Integrated video tutorials throughout
- A new design for ease of navigation across chapters

With over 400 simple, clear drawings, written explanations, exercises and video tutorials, as well as historical and theoretical background, this book is an essential visual guide for current and future architects, interior designers, landscape architects, graphic designers, video game designers, animators, and artists.

Craig Attebery is a native southern Californian. He graduated from ArtCenter College of Design in 1980, receiving a BFA with Honors. He then completed his MFA studies at Otis/Parsons Art Institute in 1984. Craig has worked as a freelance illustrator for advertising agencies, science books, and the entertainment industry, as well as creating conceptual art for JPL/NASA and the aerospace industry. Craig's illustrations have appeared in many publications, including *Newsweek* and *Time* magazine. In addition to his commercial work, he has participated in exhibitions at galleries and museums throughout the country and internationally, including the Fry Museum (Seattle, WA), the Arnot Museum (Elmira, NY), the Art Museum of South Texas (Corpus Christi, TX), and the Oceanside Museum (Oceanside, CA). His work is in the permanent collection of the de Young Museum (San Francisco, CA). Craig is a faculty member at ArtCenter College of Design, where he has taught perspective for over 20 years.

From Previous Editions

“Full of very clear illustrations with a straightforward text, knowledge of algebra and geometry is not required… . This is an excellent guide that is easy to use. It is well laid out, allowing information to be easily accessed.”

—*Ray Needham FAIA FFA FIPA FMAAT*, Building Engineer, *September 2018*

The Complete Guide to Perspective Drawing

From One-Point to Six-Point

Second Edition

Craig Attebery

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Preface

I tried to look relaxed as I sat across from the interviewer—fresh out of my sophomore year at art school, hoping to land a summer job doing artwork of some kind, any kind; I wasn't picky. The interviewer looked tired. His questions were delivered with a fatigued voice, a voice that seemed to have echoed the same question to countless interviewees. "We are looking for someone who can do perspective drawings. Can you do perspective drawings?" he asked. It was a straightforward question. My choice was clear: tell the interviewer I was up to the task, or tell the truth. Knowing the latter reply would end the interview, and feeling I had nothing to lose, I decided to … well, *stretch* the truth. I struggled for the first few years, trying to teach myself the finer aspects of perspective and not get fired in the process. A decade later I was still working for the same company, still doing perspective drawings, and finally feeling secure in my perspective abilities. So much so that when I was asked to teach a class in perspective, I was confident that I knew my stuff.

But then came the students' questions. And with them came the realization that I was not as knowledgeable about perspective as I had thought. My students asked challenging questions. Trying to find answers to these questions in publications and online sources led me nowhere. Sources that answered elemental perspective concepts were ubiquitous. But—beyond the basics—information was scarce. Once again, I was

on my own, figuring it out.

Perspective theory can be challenging. Having a detailed publication to refer to is invaluable. At the college where I teach, ArtCenter College of Design, the students are known for their passion and resolve. I knew a basic perspective text would not answer their questions—or be up to their standard. So, I made my own set of handouts. It was only a few pages at first, covering some of the more complicated aspects. Writing a book was the furthest thing from my mind. Whenever a student was having difficulty applying a procedure, I would create a handout addressing that subject. The number of handouts grew; the small set of handouts soon became a stack. After 15 years of teaching perspective, I had created several hundred handouts. When I showed them to a colleague, he said, "These are not handouts—this is a *book!*"

Well, it wasn't really a book, at least not yet. It still took some additional coaxing from students, and a timely call from Routledge Press, before the handouts were at last assembled, finalized, and transformed into this publication: *The Complete Guide to Perspective Drawing.*

I want to thank all my students for their patience, thirst for knowledge, and continual appeals for additional handouts.

Abbreviations

AUX. HL (Auxiliary Horizon Line)
AUX. MP (Auxiliary Measuring Point)
AUX. VP (Auxiliary Vanishing Point)
CV (Center of Vision)
EL (Eye Level)
GL (Ground Line)
GLVP (Ground Line Vanishing Point)
HL (Horizon Line)
HML (Horizontal Measuring Line)
LA (Light Angle)
LAP (Left Axis Point)
LAVP (Light Angle Vanishing Point)
LMP (Left Measuring Point)
LRL (Left Reference Line)
LRP (Left Reference Point)
LVP (Left Vanishing Point)
LSP (Left Station Point)
ML (Measuring Line)
MP (Measuring Point)
PP (Picture Plane)
RAP (Right Axis Point)
RMP (Right Measuring Point)
RRL (Right Reference Line)
RRP (Right Reference Point)
RP (Reference Point)

RSP (Right Station Point)
RVP (Right Vanishing Point)
SP (Station Point)
VAP (Vertical Axis Point)
VML (Vertical Measuring Line)
VMP (Vertical Measuring Point)
VP (Vanishing Point)
x. VRL (Vertical Reference Line)
VRP (Vertical Reference Point)
VSP (Vertical Station Point)
VVP (Vertical Vanishing Point)
XAP (*x*-Axis Point)

xi. xii.

Video Tutorial Content

Playlist Folder Name	Content
Introduction Video	• Introduction • Geometric objects as placeholders • Multiple solutions • Digital vs physical • Expanded information and practical applications
Tools of the Trade	• Equipment options • How to use the tools
One-Point Perspective	• Basic terms • Diagram setup • Drawing one-point perspective objects
Practical Applications	• Practical applications of reference points
Two-Point Perspective	• Diagram setup • Drawing two-point perspective objects • The problem of distant vanishing points (CH 12)
Measuring Point Geometry	• Why measuring points do what they do (CH 6 and 11)
Understanding Angles	• How to use the station point to determine angles
Ellipses	• Why ellipse guides look wrong most of the time • Why spheres are not round
Inclines	• Inclines and the measuring line • Inclines and the

measuring point • Steep inclines • Two methods

Inclined Cuboids
• The geometry of inclines • Inclines and the measuring point • Options for measuring point placement

Rotating Forms
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Perspective History
• Greeks • Brunelleschi • Alberti

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Three-Point Perspective
• Diagram setup • Measuring horizontal dimensions • Measuring vertical dimensions • Deciding on a ground plane

Three-Point Angles
• Objects not touching the picture plane

Combining Diagrams
• One- and three-point • Two- and three-point • Multiple three-point diagrams

Compound Inclines
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Shadows/Artificial Light
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Three-Point Shadows
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Anamorphic Drawing
• History and application

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• The diagram • Limitations and application

Five-Point Perspective
• The diagram • Limitations and application

Six-Point Perspective
• The diagram • Limitations and application

Miscellaneous
• Dividing lines • Intersecting shapes

https://www.youtube.com/channel/UCMhS7yhSKHTOBXiHgD0mzZQ

Introduction

Welcome to the second edition of *The Complete Guide to Perspective Drawing*. This edition has additional drawings as well as expanded chapters on ellipses and three-point perspective shadows. Most important is the addition of QR codes that are linked to instructional videos. It has been seven years since the release of the first edition, and understanding perspective is still an important tool. Despite the prevalence of computer programs and AI technology, pencils and paper are still here.

The freedom and spontaneity of mark making, the tactile quality of a writing surface and drawing instrument, and the immediacy and convenience of the human touch will remain forever seductive. The sensuality of the hand persists and will survive as a valuable aid to visual communication, as will the need to accurately place your ideas on paper. Furthermore, knowledge is empowering. As a professional, understanding the foundations of drawing, how we process images, and how we interpret what we see are principal skills. This knowledge transfers directly to your drawings, giving them an air of confidence. If you understand the geometry of lines, you have a powerful tool to create believable images.

You can avoid learning perspective—but only for a while. Those pesky drawing problems will continue to surface: the misguided lines, the trapezoidal buildings, the awkward ellipses, the floating figures, the shapes that, well, just look "off." The problems seem endless. You realize it is time to end

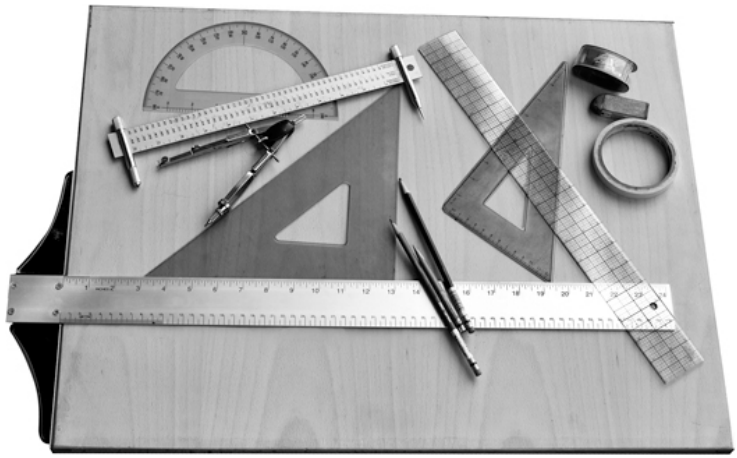
your procrastination. It is time to learn perspective. This realization is typically accompanied by a heavy sigh, for learning perspective can be overwhelming. Take a deep breath. Give yourself time to let the material sink in. It takes practice. It also takes an abnormal amount of right-brain thinking; at least, more than most artists like to do. Approach the material one problem at a time, from the simple to the complex, step by step. Have a solid understanding of the basics before you progress to the advanced.

I have tried to strike a balance between showing and explaining, so the descriptions and the images work together. Some readers connect to written descriptions; others (like me) connect to images. Both are needed to some extent. Describing the diagrams in prose is often a difficult task. I have tried to avoid describing the obvious; unnecessary wordiness contributes to confusion and tedium. In some cases, the reader may not need the descriptions at all—the drawings may tell the story.

xiv. Start at the beginning of this book, as the information builds on previous chapters. Without the foundations supplied from the earlier sections, the rest of the book may be perplexing. There are step-by-step guides for each drawing. The instructional illustrations use basic geometric shapes as placeholders for real world objects. Depending on its proportion and scale, a cuboid can represent a building, a car, or a person. All objects can be reduced to simple geometric forms. You may wish to use colored pencils to color code the procedures. Practice by using the worksheets (available as a download from the Routledge website). As you advance through the book, it may be helpful to review previous sections. This will ensure you don't forget what you have learned. Reviewing the material also assists in gaining a deeper understanding of the procedures. Keep in mind there are many solutions to any given problem. There is no one correct procedure. There is, however, only one correct answer, one correct result—just different ways to achieve it.

After becoming well versed in perspective theory, you will be

able to find various solutions to any given problem. These solutions become evident when you understand the “whys” as well as the “hows.” I want this book to illustrate how to draw accurately but also explain why the procedures work the way they do. I have attempted to create a book for beginners and a book for the advanced. I want to tackle the difficult problems as well as the basic problems, to create (as much as possible) a complete perspective book. That being said, it is impossible to include solutions to every scenario. The purpose of this book is to give you the information needed to extrapolate from the given samples and to find a resolution to specific problems not addressed here. Remember: with knowledge, there is nothing too difficult to draw.

xv. 

Tools of the Trade

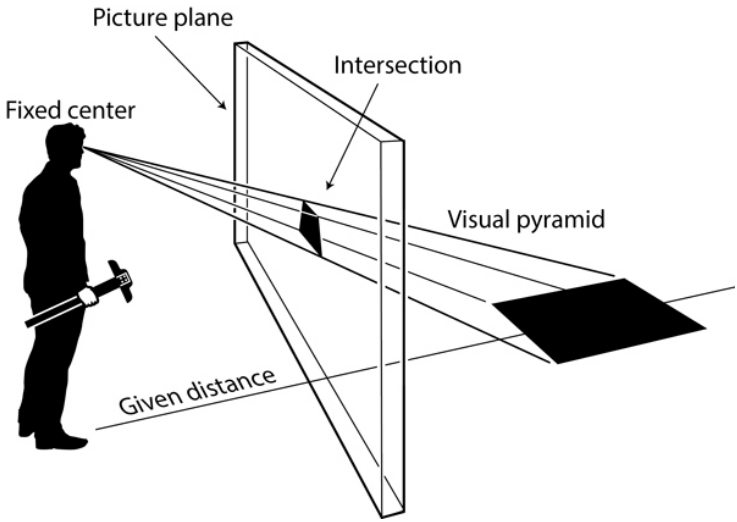
Here is a list of equipment you will find useful. Perspective drawing requires precise angles and dimensions. Having the proper tools and understanding how to use them is important to creating successful images. You will need:

- A surface to work on. This can range from a drafting table to a drafting board (pictured).
- Something that will draw parallel lines. This can range from a drafting machine to a t-square (pictured).
- 45° and 30°/60° triangles. In addition to creating these angles, they are also used to draw vertical lines.
- A protractor. Useful to draw angles other than those drawn by the triangles.
- A ruler. One made out of transparent material is best.

- Color pencils. Perspective drawings can become complicated. Color coding your procedures is a helpful technique.
- A sharpener. Keeping a nice point on your pencils is important.
- Tracing paper. Working with overlays is another method to keep elements in your drawing organized.
- A compass. A beam compass is also useful for making circles and arcs that are too large for a standard compass.
- Drafting tape. Keep your paper securely fastened to your drawing board.
- An eraser. For that rare occasion when you make a mistake. xvi.

1. 2.

part one
The Basics



3.
Figure 1.1 The intersection of the picture plane within Alberti's "visual pyramid." **Return to text.**⏎

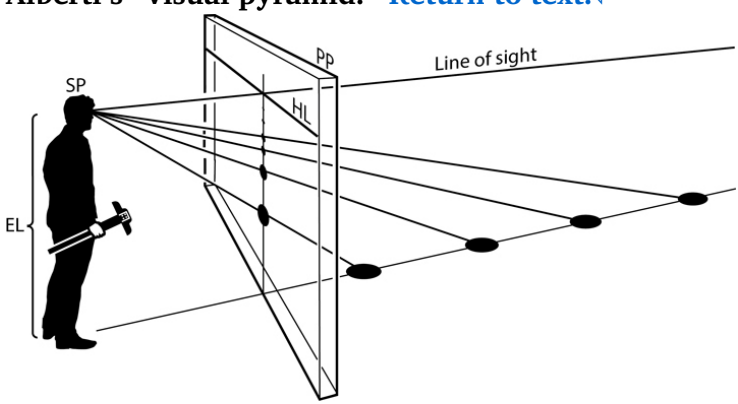


Figure 1.2 As the dots move farther from the picture plane, they become closer to the eye level. Objects at infinity, like the horizon line, are depicted at eye level. **Return to text.**⏎ 6.

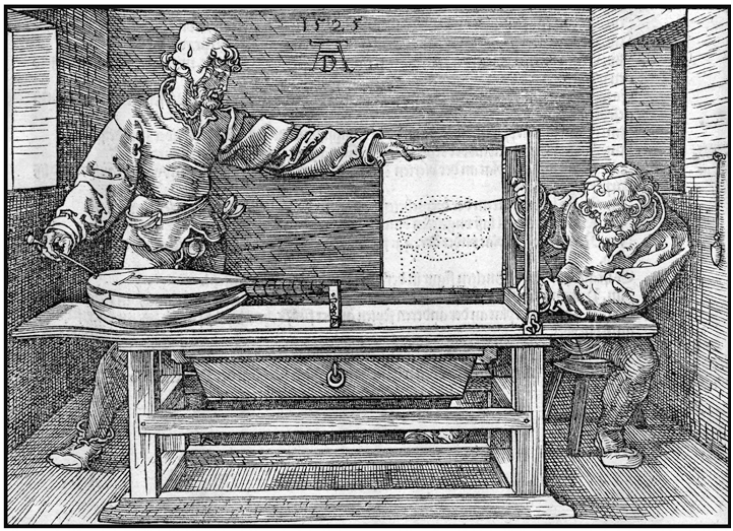


Figure 1.3 Albrecht Dürer, *Underweysung*, 1525. This etching shows the picture plane (the frame), the station point (the hook attached to the wall), and the visual pyramid (the string attached to the lute). **Return to text.**⏎

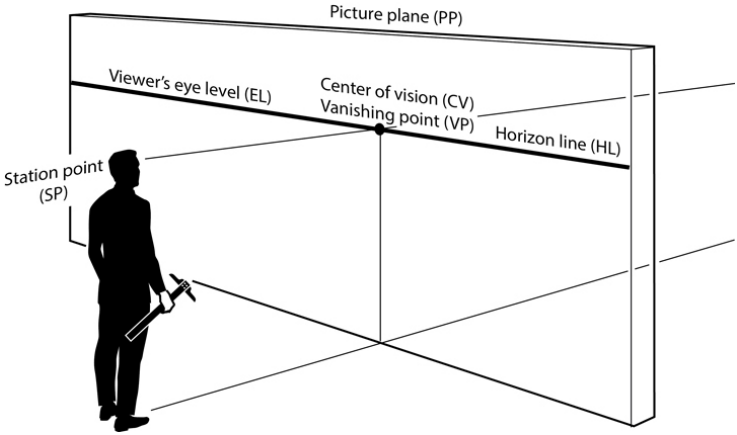


Figure 1.4 This illustration shows the relationship between the station point, picture plane, eye level, horizon line, and vanishing point. **Return to text.**⏎

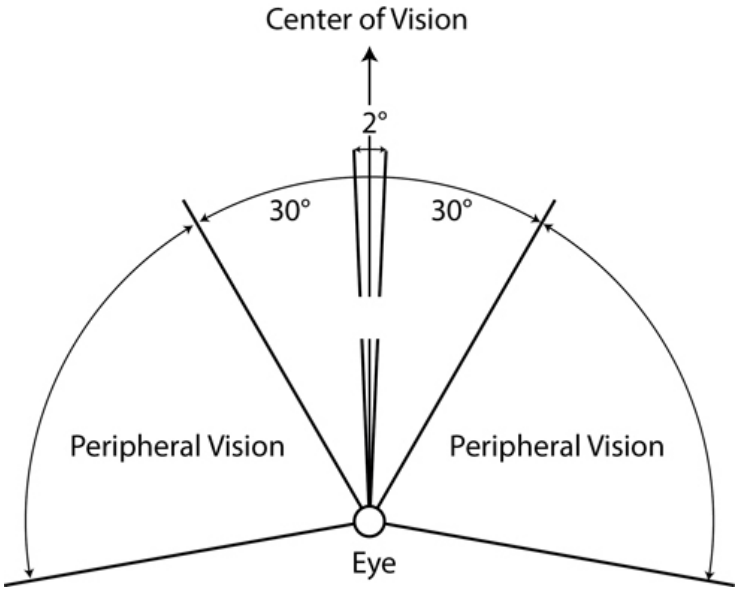


Figure 1.5 Peripheral vision is beyond 180°. The cone of vision is 60°, and the focal area is 2°. **Return to text.**⏎

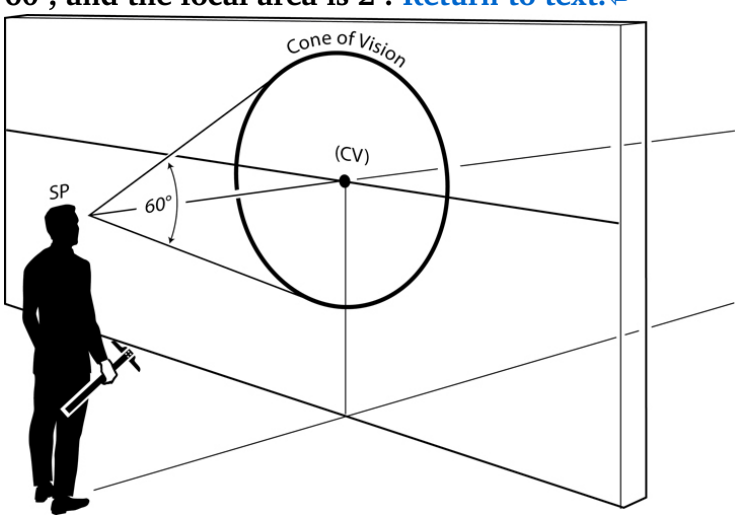


Figure 1.6 The cone of vision is 60° from the station point. **Return to text.**⏎

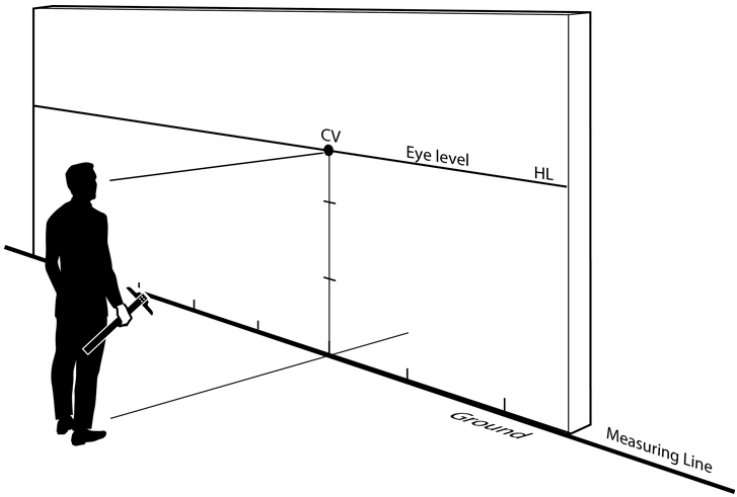


Figure 1.7 The viewer's eye level equals the distance from the measuring line to the horizon line. The placement of the measuring line determines the height of the viewer. Return to text. ⏎ 10.

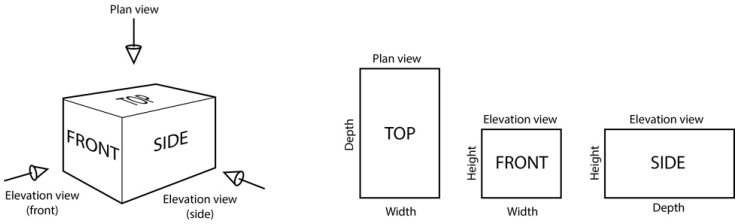


Figure 1.8 Plan and elevation views show only two dimensions. Return to text. ⏎ 11.

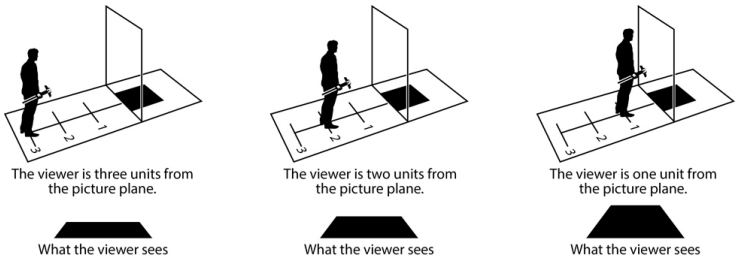


Figure 1.9 Moving the viewer changes the object's shape but not the size. The width at the picture plane remains unchanged regardless of where the station point is located. Return to text. ⏎ 12.

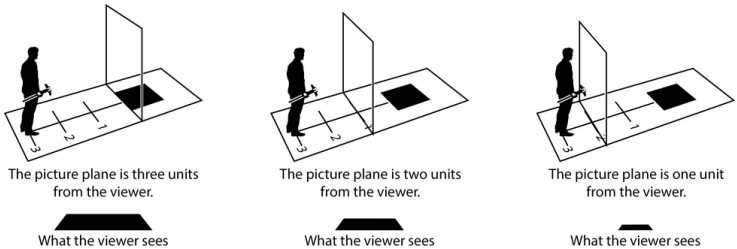


Figure 1.10 Moving the picture plane changes the object's size but not the shape. When the picture plane is closer to the station point the image is smaller. When the picture plane is farther away from the station point the image is bigger. The shape of the image does not change, only its scale. **Return to text.**⏎

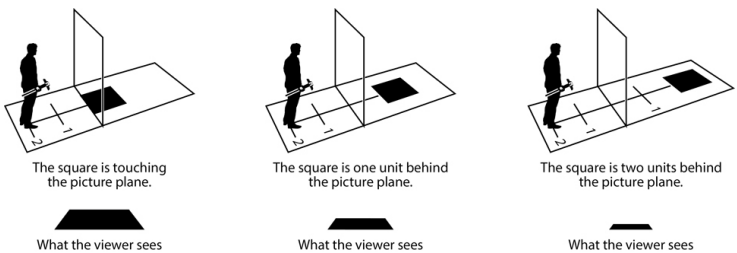


Figure 1.11 Moving the object changes the size and shape. **Return to text.**⏎

chapter 1
Basic Perspective Terms

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> *4. A painting is the intersection of a visual pyramid at a given distance with a fixed center.*
>
> —Leon Battista Alberti, *On Painting*, 1435

This quote is far from the romantic verse commonly used to describe creative endeavors. Nonetheless, Alberti's clinical

delineation encapsulated a revolutionary transformation in art production: a revolution based on science. No longer did artists need to base their images on speculation and assumption, on convention and estimation. Artists could now depend on verifiable data. Art and reason became allies.

As perspective's value became apparent, so did its deft requirements. Perspective procedures can be challenging. The alternative—drawing without perspective techniques—is merely guesswork. Perspective's most valued asset is its ability to accurately portray objects, to assess dimensions, and to project those dimensions spatially. Perspective produces an uncompromised image, sometimes a surprising image. Drawing is often anti-intuitive, and shapes can appear different than expected. It is not a requirement to plot all images using perspective guidelines, but by practicing perspective techniques, a sense of how foreshortened shapes present themselves can be developed. Then, when the artist is sketching from observation or imagination, the skillset learned from studying perspective becomes a valuable tool to base their estimations on.

The word perspective derives from the Latin *perspirere,* to look through. Alberti's definition arose from the realization that when a sheet of glass is placed between the viewer and the world and the view traced, the perspective is flawless. This vision—as self-evident as it may seem—changed art production forever. Alberti's statement is concise, but his terms are abstract, so they will be examined further.

The equation consists of a viewer, a sheet of glass, and an object to be drawn. The viewer is Alberti's "fixed center." It is fixed because the viewer must remain stationary. A drawing cannot begin from one point of view and be finished from another, because a different location results in a different image.

Light makes the world visible. Rays of light reflect from objects and project to the retina, converging at the viewer's eye. This is Alberti's "visual pyramid." The rays "intersect" the sheet of glass (known as the picture plane). The intersection of these rays on the picture plane creates the projected image seen, a

perfect representation of the world (Figure 1.1).

From its inception, perspective was met with resistance. Change is difficult; artists had been creating images for hundreds of years without perspective. Painters found this new method of spatial organization difficult, confusing, and frankly unnecessary. But some early converts (one of the most noted being Masaccio, 1401–1428) embraced the new technology, with breathtaking results. Others waited, but eventually the popularity of these new and exciting images forced the holdouts to convert. The procedures were daunting. But competing as an image maker in this new world required a new prerequisite: perspective proficiency.

Perspective technique evolved over the years from an approach using projection (Chapter 15) to one based on geometry (Chapter 6). But mastering the thirteen books of Euclid's *Elements* is not required to understand perspective. The critical knowledge the 5. artist requires is how to read a ruler, that there are 360° in a circle, and what an isosceles triangle is (a triangle with two sides of equal length).

As the understanding of geometry and its relationship to perspective evolved, so did the methods. Perspective terms have also changed since 1413. For example, six hundred years ago the term vanishing point did not exist; it was called a centric point. The language of perspective has evolved—as all language does—and today the term centric point has vanished. Likewise, the term distance point was once used for what is now called a measuring point. Variations in terminology still exist. When perusing publications that discuss perspective, different terms may be used to describe the same thing.

Basic Terms

To begin, some basic perspective terms will be defined. These terms are used throughout the book, so it is important that their meaning and function be understood.

Station Point

The station point (SP) represents the viewer, specifically the viewer's eye. A perspective drawing is created using only one eye. Creating a perspective drawing using a pair of eyes would result in two slightly different images. A stereographic (3-D) image is made using two station points. A single image requires a single station point. It is called a station point because it must remain stationary (the station point is Alberti's "fixed center").

Eye Level

The eye level (EL) is the distance from the ground to the viewer's eye.

Horizon Line

The horizon line (HL) is the edge of the earth, where ground meets sky.

The edge of the earth is aligned with the viewer's eye level. Whether flying in a plane or sitting on the ground—the horizon is always at eye level. Why is this? The following exercise will explain. Stand in front of a piece of glass, place a small object on the ground, and trace its position on the glass. Then place the object farther away and trace its new position. It is now higher on the glass (closer to eye level). The farther away an object is, the higher it will appear on the glass. Objects move up the glass as they move farther away. At some point, depending on its size, the object will no longer be able to be seen. Larger objects can be seen from a greater distance and are thus higher on the glass. They appear closer to eye level. If something is *very* large and is *very* far away, it will disappear *at* eye level. For example, the edge of the Earth disappears at eye level, at infinity (Figure 1.2).

Picture Plane

The picture plane (PP) is an imaginary window positioned between the viewer and the world (Figure 1.2). It is always 90° to the line of sight (the exception being anamorphic perspective). The orientation and shape of the picture plane

defines the type of perspective. If the picture plane is perpendicular to the ground, objects are in one- or two-point perspective. If the picture plane is angled to the ground, objects are in three-point perspective. In four-, five-, and six-point perspective, the picture plane is curved.

Albrecht Dürer created a perspective machine that demonstrated Alberti's theory and how the picture plane, station point, and visual pyramid functions (Figure 1.3). One end of a string was attached to the wall (fixed center) and another to the object (in this example, a lute). The string represented the visual pyramid. Using movable cross hairs fixed to a frame, the intersection of the string to the picture plane was plotted. The frame represented the picture plane. When the cross hairs were in position, the string was removed. The hinged door was closed, and a dot placed where the cross 7. hairs aligned. The door was then opened, the string was attached to a different spot on the lute, and the process was begun again. This was not only tedious but apparently a two-person job.

Center of Vision

The center of vision (CV) is where the viewer is looking (also known as the focal point).

In one- and two-point perspective the line of sight is parallel to the ground plane, and the center of vision is on the horizon line. In three-point perspective the line of sight is angled to the ground plane and the center of vision is above or below the horizon line.

In day-to-day activities, a person's focus darts from place to place as they assess their surroundings. A perspective drawing, however, is from a specific focus point. Because the viewer can only look at one place at a time, they can only have one center of vision.

Vanishing Point

The vanishing point (VP) is at infinity. Objects get smaller as they recede in space; therefore at infinity all objects disappear.

Vanishing points can be on the horizon line, above the horizon line, or below the horizon line. There can be an unlimited number of vanishing points, but there is only a single one-point vanishing point. This single point 8. is always located at the center of vision. Figure 1.4 demonstrates how the vanishing point and previously discussed terms relate to each other.

Cone of Vision

A person can focus on only a small area, about 2° of the surrounding environment. Peripheral vision, however, is quite large, beyond 180°. The cone of vision lies between them (Figure 1.5). The cone of vision is a 60° circle that defines the viewer's image area (the area to be drawn within). The center axis of this circle is the focal point. Imagine looking through a cone with a 60° angle centered along its axis. Its intersection with the picture plane creates a circle that defines the size of the cone of vision (Figure 1.6). The farther away the viewer is from the picture plane, the larger the cone of vision and the 9. circle become. Beyond the confines of the 60° cone, distortion becomes problematic. Shapes look stretched, tilted, and corners no longer look like right angles. The cone of vision is drawn to warn the artist that excessive distortion waits beyond its border. Inside the 60° cone distortion still exists but is less apparent.

Measuring Point

The measuring point (MP) is a tool used to measure foreshortened lines. Every vanishing point has a dedicated measuring point. Before perspective, measuring was a guessing game. Understanding how math relates to drawing enabled artists to draw accurate dimensions. The placement of a measuring point is specific and determined by geometry. Calculating measuring points is discussed further in Chapter 3.

Measuring Line

The measuring line (ML) is the ruler and determines the drawing's scale. A 1:1 scale creates a drawing that is actual size.

Every foot or meter of the object being drawn equals that dimension on the paper. Drawing a house using a 1:1 scale would require a piece of paper as large as the house. To avoid this, the scale can be changed. A 1:2 scale means every unit on the drawing equals 2 units in the real world; therefore, the drawing is half scale. The size of the paper and the subject being drawn determine the scale to use.

The measuring line is typically placed on the picture plane at the ground level. In this position, the measuring line not only determines the scale, it also determines the height of the viewer. Since the horizon line is at the viewer's eye level and the measuring line is on the ground, the distance between the horizon line and measuring line equals the distance between the viewer's eyes and the ground plane (Figure 1.7).

Plan View

A plan view is an orthographic drawing from above. A plan view has no perspective; it shows only two dimensions: width and depth (Figure 1.8).

Elevation View

An elevation view is an orthographic drawing from the front, back, or side. An elevation view has no perspective. Like plan view, only two dimensions are shown: height and width (front or back elevation view), or height and depth (side elevation view) (Figure 1.8).

Station Point and Picture Plane Dynamics

When a viewer sees an image, the shape perceived is determined by the relationship between three elements: the station point, the picture plane, and the object. When the relationship between these three elements changes, the object seen also changes. To gain a better understanding of this phenomenon, each of these elements will be examined more closely.

Station Point

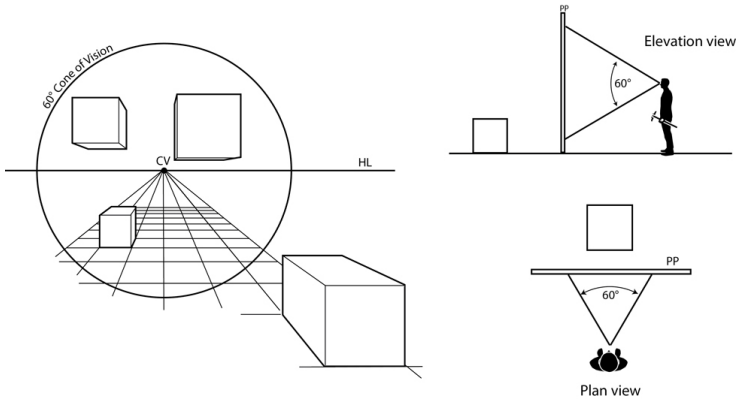
The station point can be close to the picture plane, or far away. The farther away the viewer is from the picture plane, the more foreshortened depth appears. When the viewer moves closer to the picture plane the foreshortening is less severe. Width, however, is not affected (Figure 1.9).

Picture Plane

The picture plane can be positioned anywhere between the station point and the horizon line. The closer the picture plane is to the viewer the smaller the object appears. The farther the picture plane is from the viewer, the larger the image appears. The perspective does not change. The images are identical in shape but are different sizes (Figure 1.10).

Object

When the image is closer to the picture plane it is larger and less foreshortened. As the image moves farther from the picture plane it becomes smaller and more foreshortened. The object's size *and* shape are affected (Figure 1.11).



13.

Figure 2.1 In one-point perspective vertical and horizontal lines are parallel to the picture plane. Objects outside of the cone of vision are distorted. A cube will look more like a rectangle. **Return to text.**⏎

Figure 2.2 Albrecht Dürer, *St. Jerome in His Study* (engraving), 1514, the Metropolitan Museum of Art, object number 19.73.68. The chair to the right of St. Jerome is an early example of two-point perspective. **Return to text.**⏎

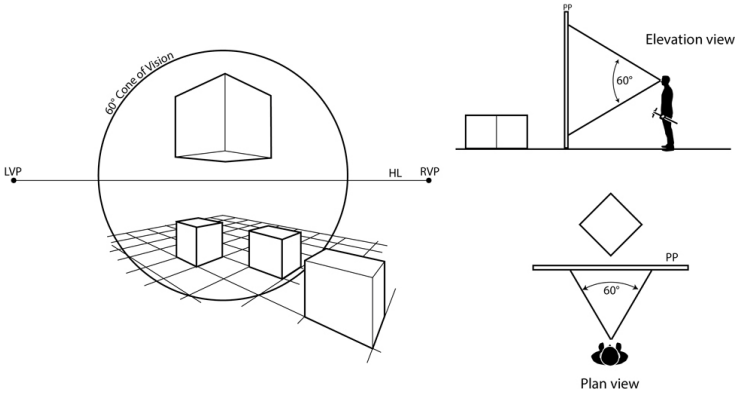
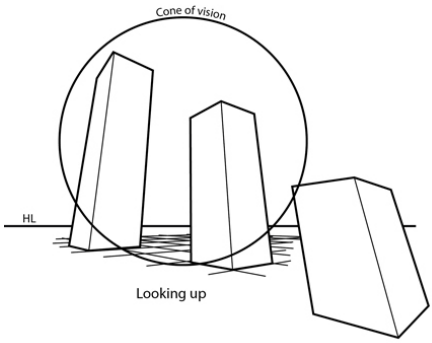
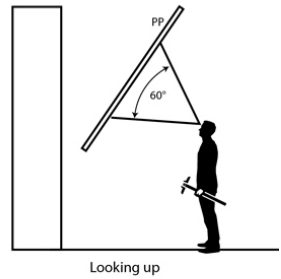
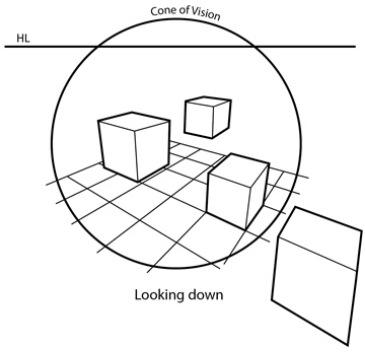


Figure 2.3 In two-point perspective, vertical dimensions are parallel to the picture plane, and horizontal dimensions are angled to the picture plane. Objects outside the cone of vision are distorted; cubes look rhomboid, the corners not appearing to be right angles. **Return to text.**⏎ 15. 16.

Figure 2.4 Carlo Urbino, Detail from the *Codex Huygens*, Morgan Library & Museum, NY. **Return to text.**⏎







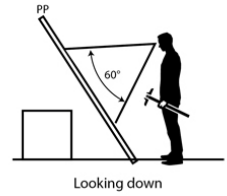
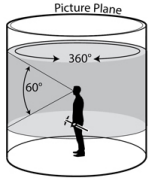
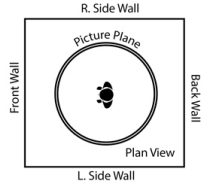
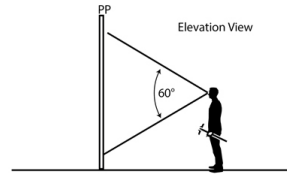
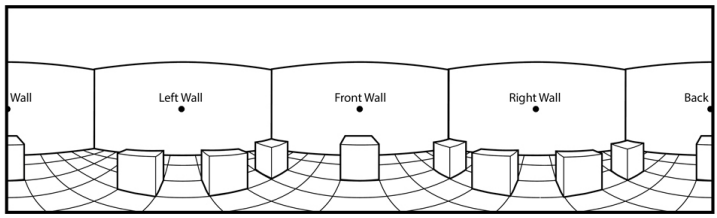


Figure 2.5 In three-point perspective no lines are parallel to the picture plane. Objects outside the cone of vision are distorted. They look stretched and tilted. **Return to text.**⏎

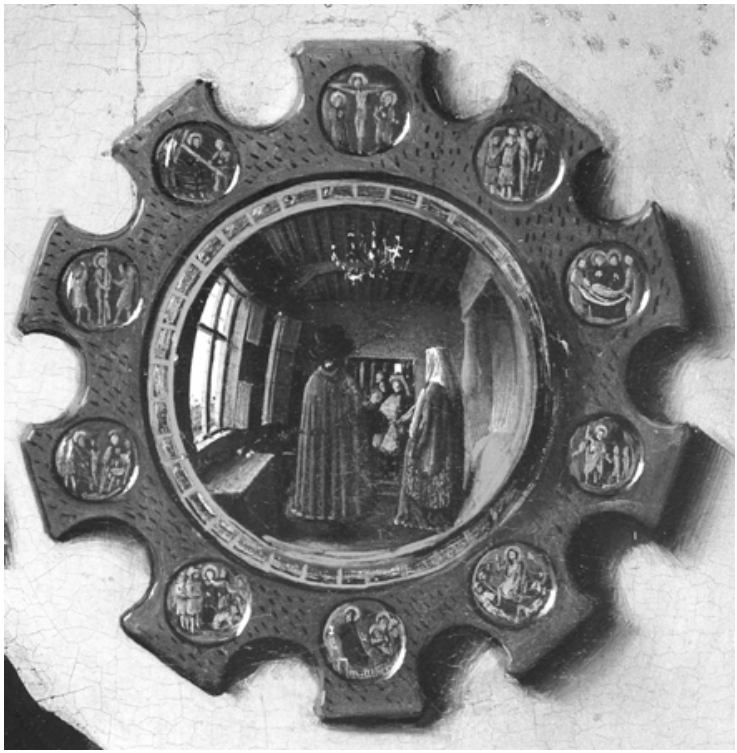








17. **Figure 2.6 In four-point perspective vertical lines are straight and horizontal lines are curved.** **Return to text.**⏎



18. **Figure 2.7 Jan van Eyck *The Arnolfini Portrait* (detail), 1434, National Portrait Gallery, London.** **Return to text.**⏎

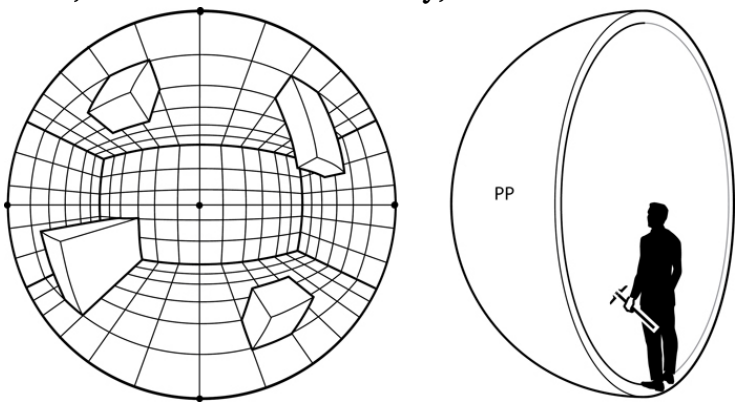


Figure 2.8 In five-point perspective, the picture plane is a hemisphere. **Return to text.**⏎ 19.

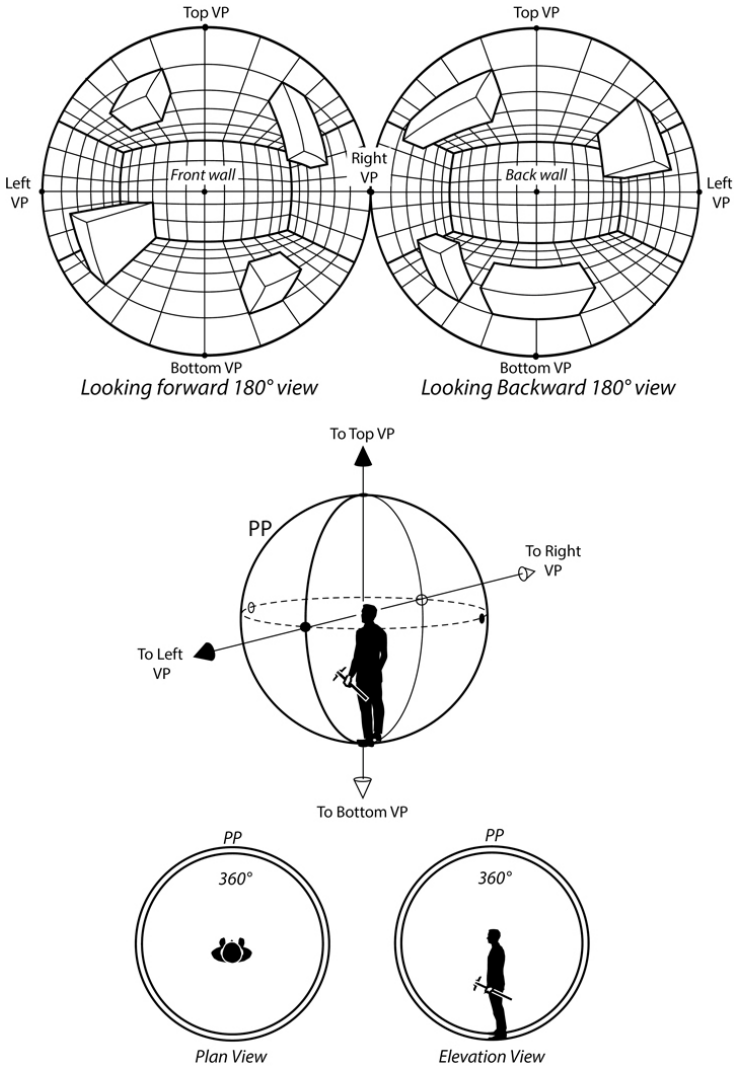


Figure 2.9 In six-point perspective, the picture plane is a sphere with the station point at its center. **Return to text.**⏎ 20.

chapter 2
One- Through Six-Point

Perspective, an Overview

DOI: 10.4324/9781003488101-3

14. In the world of perspective, there are six ways a viewer can be oriented to the *mise-en-scène*. Each orientation results in a different diagram, and each diagram depends on the relationship of the viewer to the picture plane and to the object being drawn. The relationship of these three items (as well as the shape of the picture plane) determines the diagram used. Perspective diagrams can be from one-point all the way up to six-point perspective. Detailed instructions are given for these orientations in subsequent chapters, but first, a brief overview of them follows before examining their finer aspects.

One-Point Perspective

In 1435 Leon Battista Alberti published *On Painting*, the first book to diagram perspective—specifically, one-point perspective. In one-point perspective, vertical and horizontal dimensions are parallel to the picture plane. Vertical lines are drawn perpendicular to the horizon line, and horizontal lines are drawn parallel to the horizon line. Depth is foreshortened. These foreshortened lines are oriented 90° to the picture plane and connect to the center of vision (Figure 2.1).

Two-Point Perspective

Objects drawn in two-point perspective appear early in the sixteenth century (Figure 2.2). In two-point perspective, horizontal lines are angled to the picture plane and thus foreshortened. They connect to a left vanishing point (LVP) or right vanishing point (RVP). Only vertical dimensions are parallel to the picture plane and are drawn as true vertical lines (Figure 2.3).

Three-Point Perspective

A rudimentary understanding of three-point perspective appears in examples from the *Codex Huygens*, a sixteenth-century Renaissance manuscript once thought to be the work of Leonardo da Vinci. This manuscript demonstrates the foreshortening effect of looking up: a worm's-eye view (Figure 2.4). In three-point perspective, no lines are parallel to the picture plane. The picture plane is angled to the ground, because the viewer is looking up or down at the image. The center of vision is above or below the horizon line. There is a left, right, and vertical vanishing point, and all lines are foreshortened (Figure 2.5).

Four-Point Perspective

Before artists understood the cone of vision, many unwittingly attempted wide-angled views—with unfortunate results. They had no way to compensate for the effects of distortion caused by a flat picture plane.

Four-point perspective is a panorama view. It displays information normally unseen. There are four vanishing points, and each is 90° apart. Horizontally, the picture plane is curved and surrounds the viewer like a cylinder. This creates a 360° image area. Vertically, the picture plane is flat. Therefore, to prevent distortion, the vertical image area remains at 60°. Vertical lines are parallel to the picture plane and are drawn straight. Horizontal lines are not parallel to the picture plane and are drawn curved (Figure 2.6).

A variation on the panorama theme is to turn the picture plane 90° (a vertical cylinder). This orientation creates a four-point view from zenith to nadir.

Five-Point Perspective

Curvilinear perspective, sometimes called "fish-eye," can be traced to the infancy of perspective. Jan van Eyck's painting,

The Arnolfini Portrait, depicts a reflection on a curved mirror (Figure 2.7). The science surrounding curvilinear perspective was not fully understood, but artists had many opportunities to study the appearance of lines reflected on curved surfaces. Polished stones used as mirrors have been found dating back to 6000 BC.

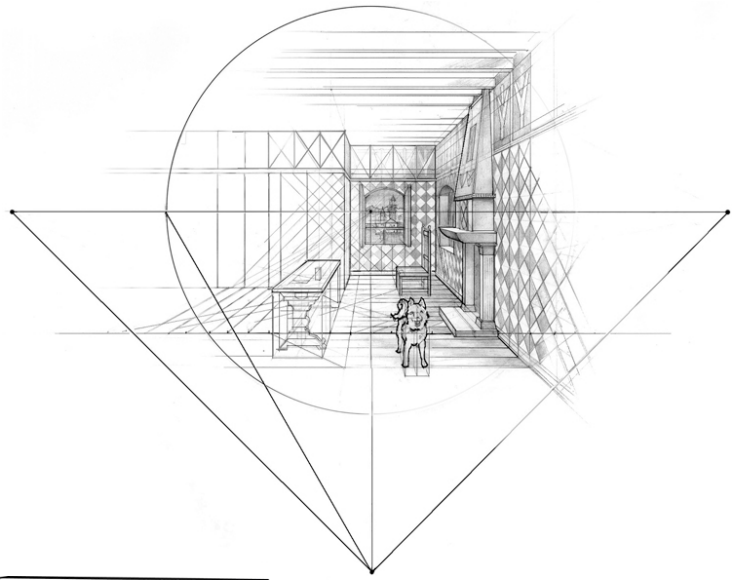
Early curvilinear perspective was confined to reflected images. However, curvilinear perspective can be applied to real objects. In five-point perspective, the picture plane is a hemisphere. Five-point perspective creates a 180° image. Everything is depicted from east to west and from north to south. There is a vanishing point at the top of the hemisphere and one at the bottom, one to the left and one to the right. The fifth vanishing point is at the center of vision (Figure 2.8)

Six-Point Perspective

A six-point image displays everything in front of the viewer and everything behind the viewer—a 360° image. The picture plane is a sphere. The two images are typically displayed side by side (Figure 2.9).

21. 22.

part two
One-Point



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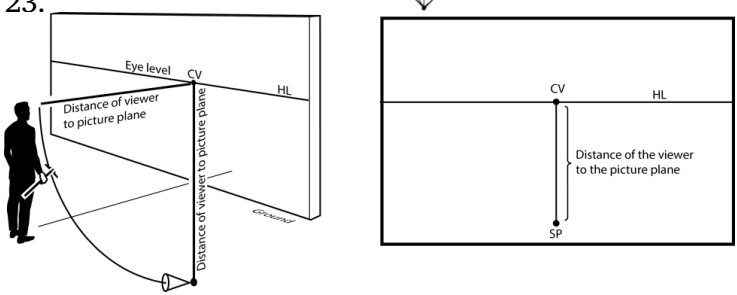
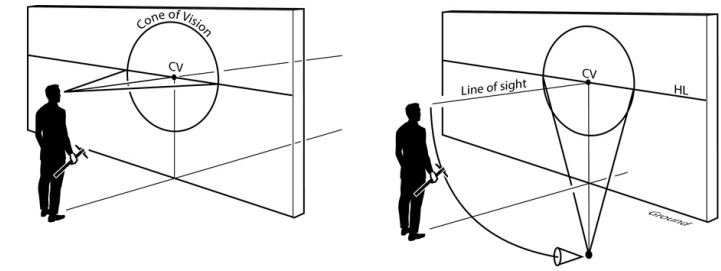


Figure 3.1 Establishing the distance from the viewer to the picture plane. **Return to text.**⏎



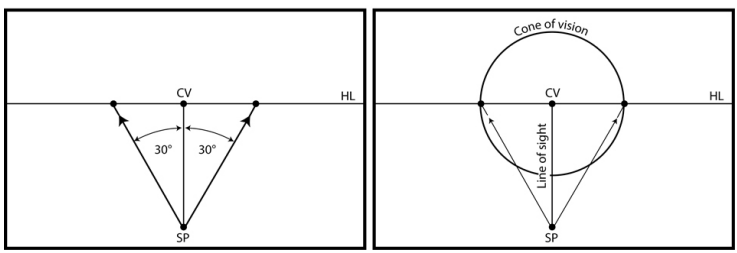


Figure 3.2 The cone of vision is a circle created from a 60° cone projected from the station point. **Return to text.**⏎ 25.

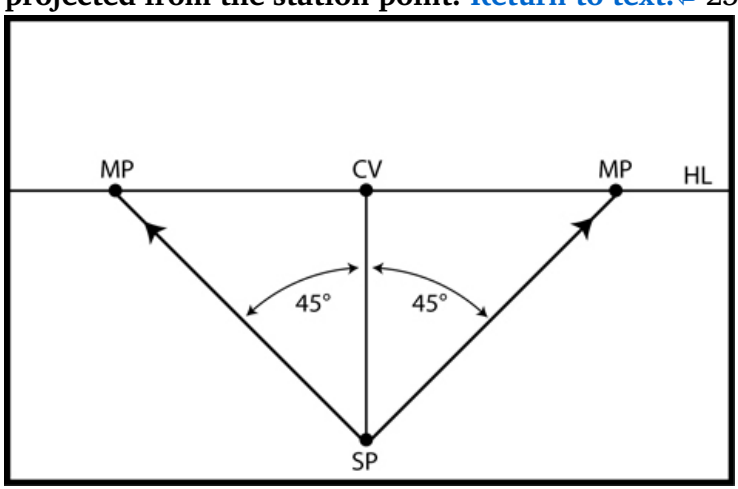


Figure 3.3 One-point measuring points are 45° from the station point. **Return to text.**⏎ 26.

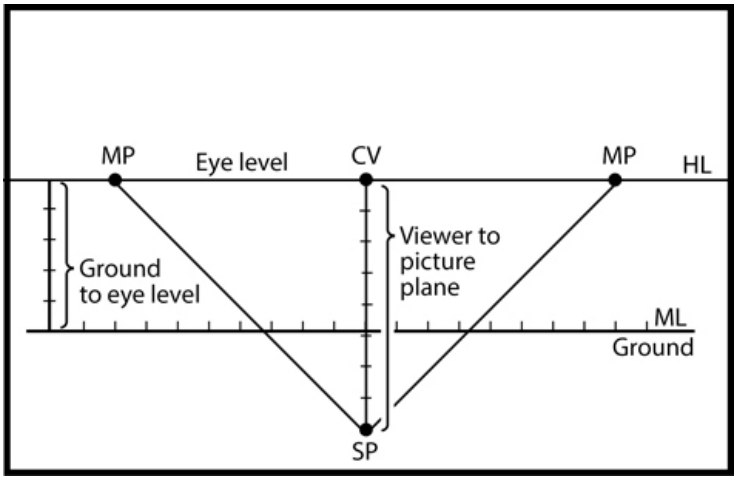


Figure 3.4 The measuring line defines the scale. The distance from the horizon line to the measuring line defines the height of the viewer (5 units tall in this illustration). The distance from the center of vision to the station point is how far the viewer is from the picture plane (8 units in this illustration). **Return to text.**⏎

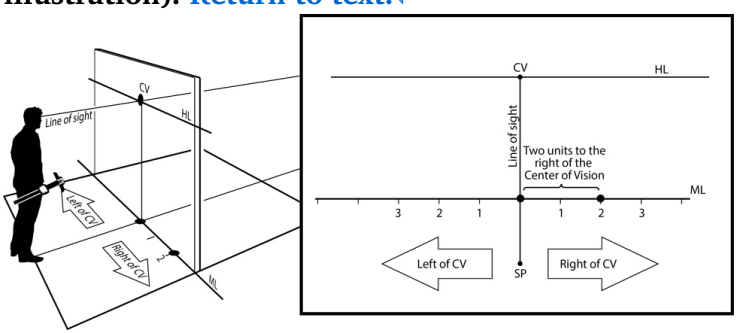
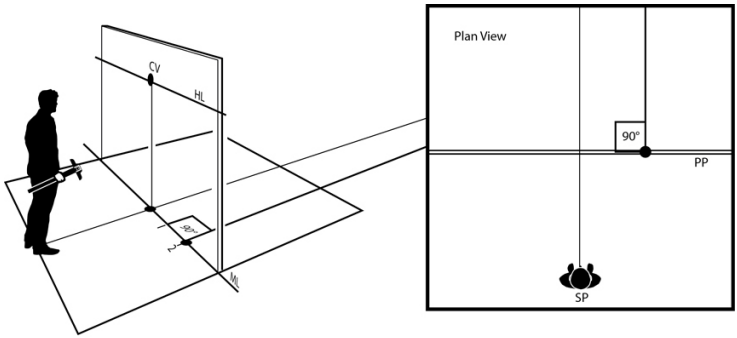


Figure 3.5 Measure width by counting units to the left or right of the line of sight. **Return to text.**⏎ 27.



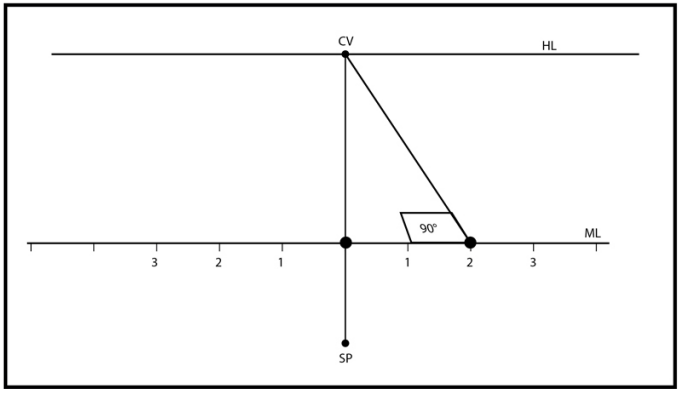


Figure 3.6 Lines that are 90° to the picture plane connect to the center of vision. **Return to text.**⏎

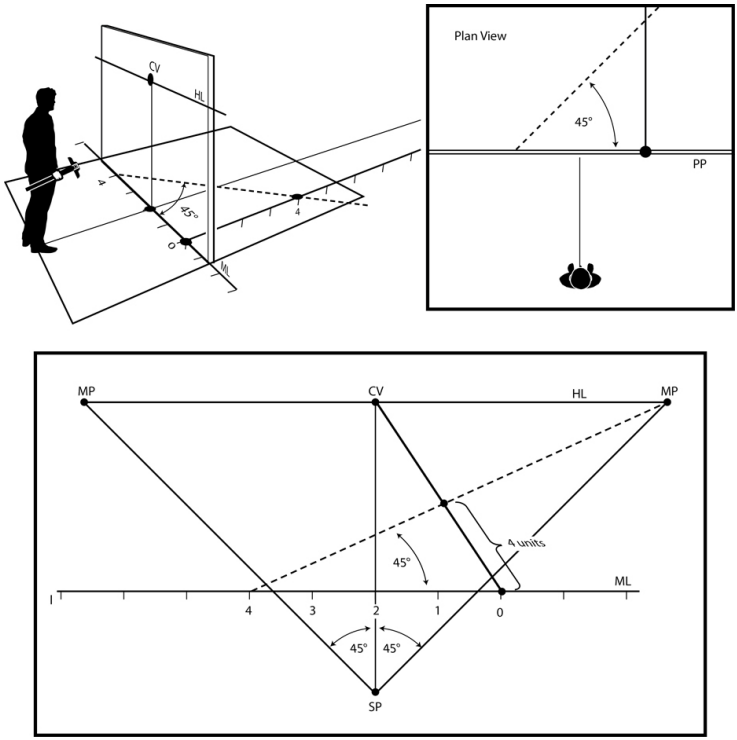


Figure 3.7 Use a measuring point to measure lines connecting to the center of vision. The measuring point draws a foreshortened isosceles triangle. Return to text. ⏎ 28. 29.

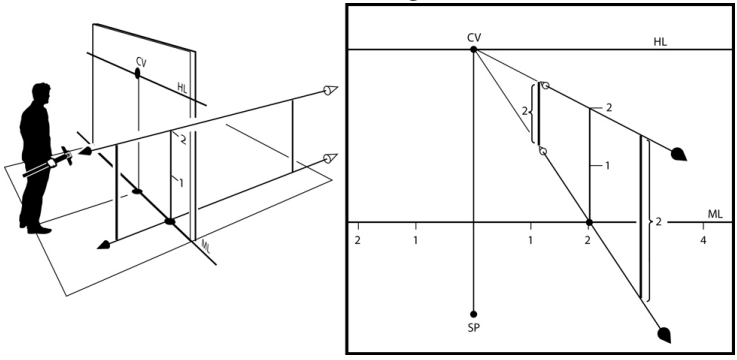
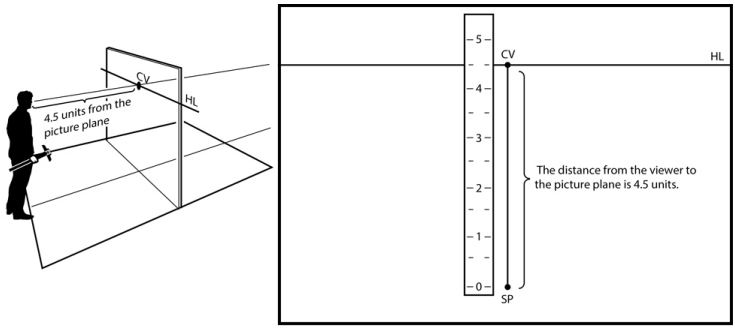


Figure 3.8 Measure height by turning the measuring line vertically. Height can be projected forward or backward using the center of vision. Return to text. ⏎



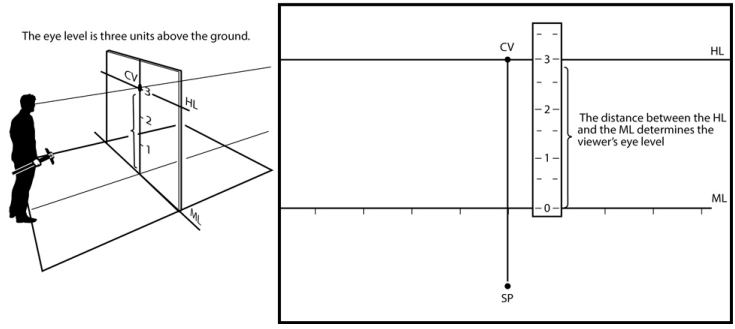


Figure 3.9 Defining the viewer's height and distance from the picture plane. **Return to text.**⏎ 30.

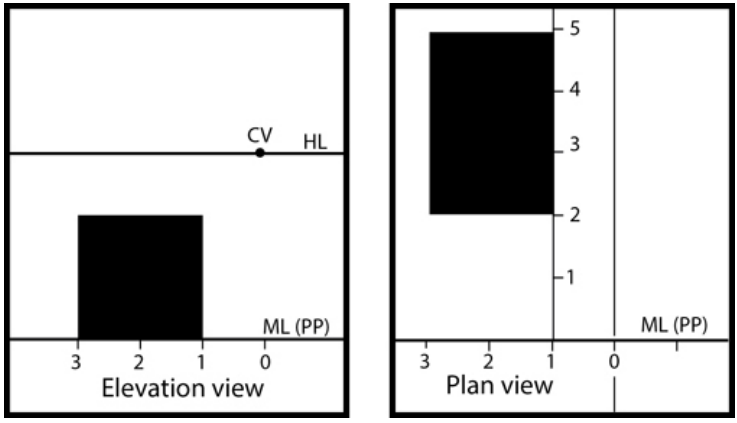
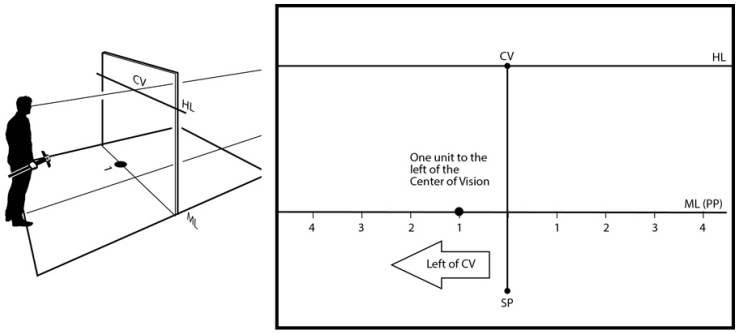


Figure 3.10 The elevation view shows the box 1 unit to the left of the center of vision. The plan view shows the box 2 units behind the picture plane. **Return to text.**⏎ 31.



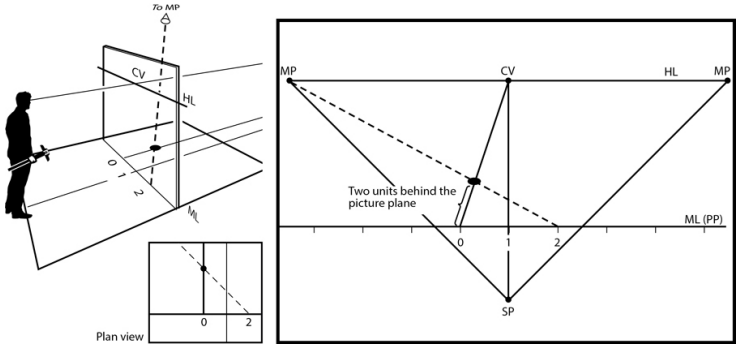


Figure 3.11 The dot represents the front right corner of the box. It is 1 unit to the left of the center of vision and 2 units behind the picture plane. **Return to text.**⏎

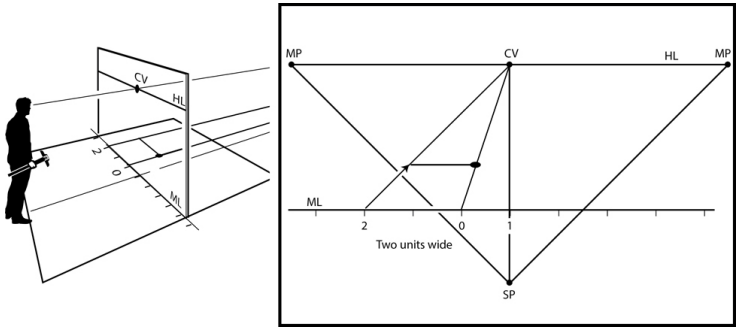


Figure 3.12 Measure the width of the box along the measuring line and project the dimension backward using the center of vision. **Return to text.**⏎ 32.

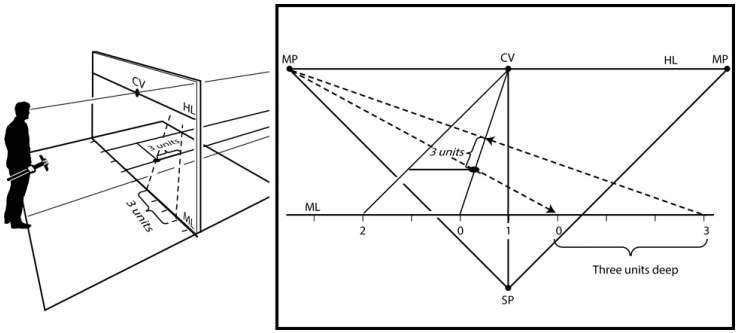


Figure 3.13 Use the measuring point to determine depth. **Return to text.**

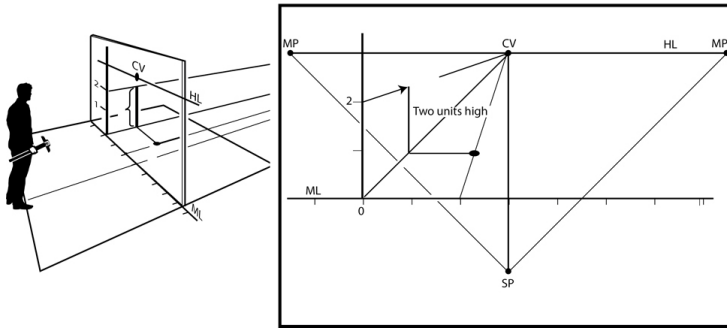


Figure 3.14 Measure up from the measuring line; then project the height back to the desired location using the center of vision. **Return to text.** 33.

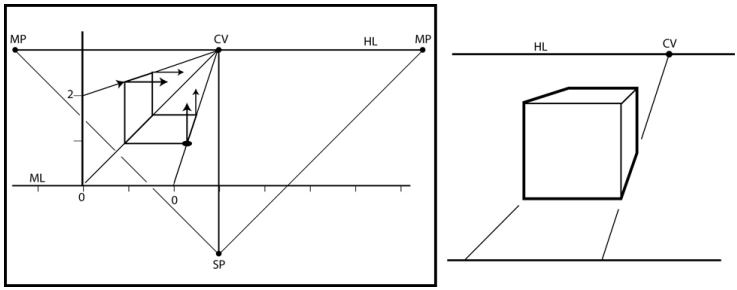


Figure 3.15 The completed box. **Return to text.**

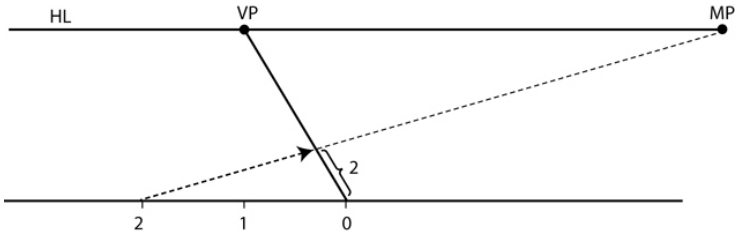
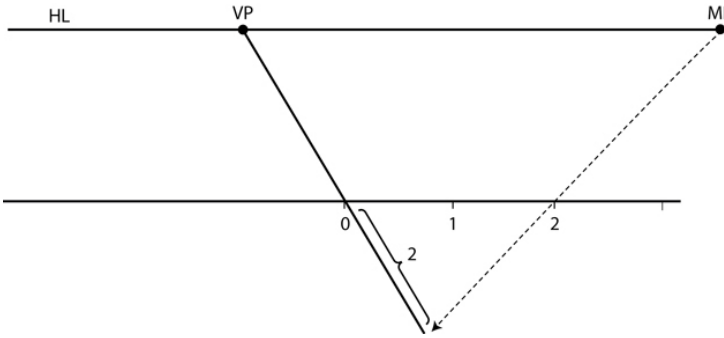


Figure 3.16 Measuring 2 units behind the picture plane. **Return to**



text.⏎

Figure 3.17 Measuring 2 units in front of the picture plane.

Return to text.⏎

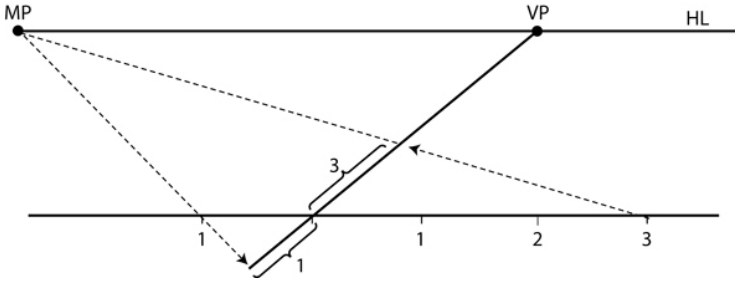


Figure 3.18 Measuring a line that straddles the picture plane. This line is 4 units long (1 unit in front of the picture plane and 3 units behind the picture plane). **Return to text.⏎**

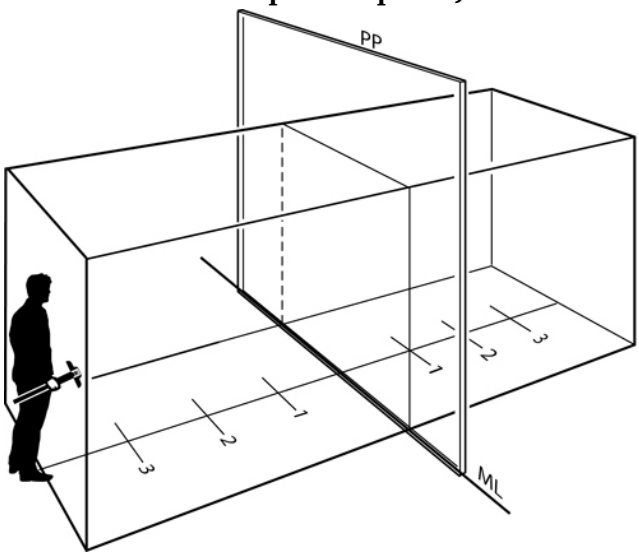


Figure 3.19 The viewer is 4 units in front of the picture plane. The back of the room is 4 units behind the picture plane.

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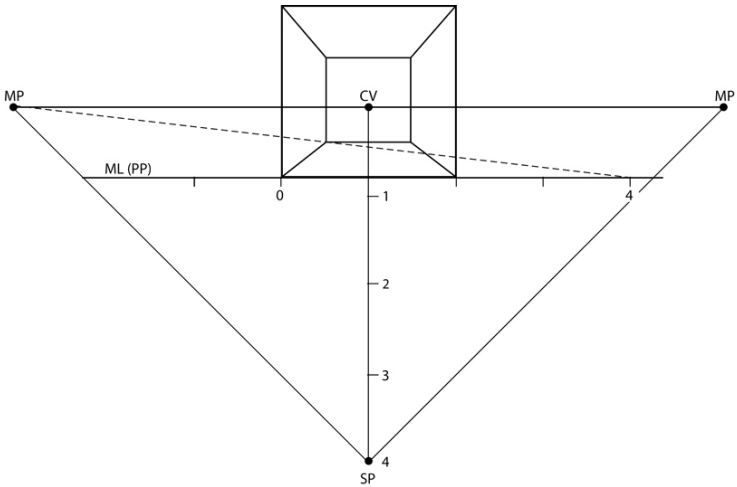


Figure 3.20 Measuring 4 units behind the picture plane. **Return to text.⏎** 36.

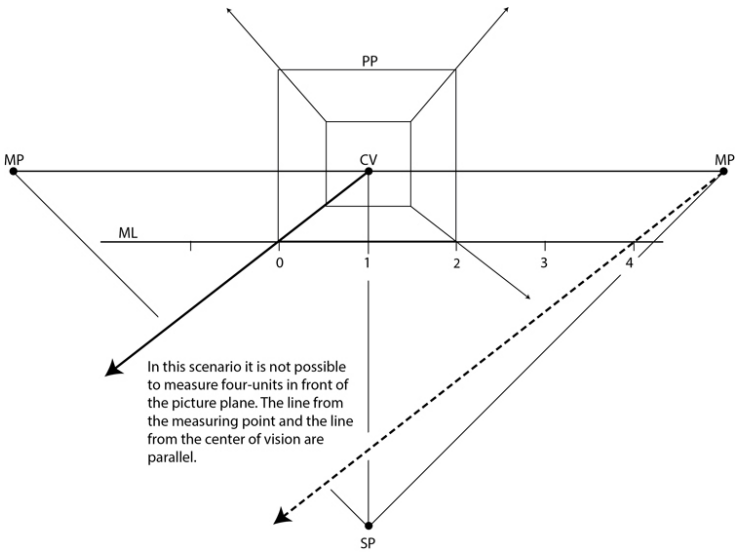


Figure 3.21 The beginning of the room is 4 units in front of the picture plane. The viewer is also 4 units in front of the picture plane. This creates a distance at infinity and can not be plotted on the picture plane. **Return to text.⏎**

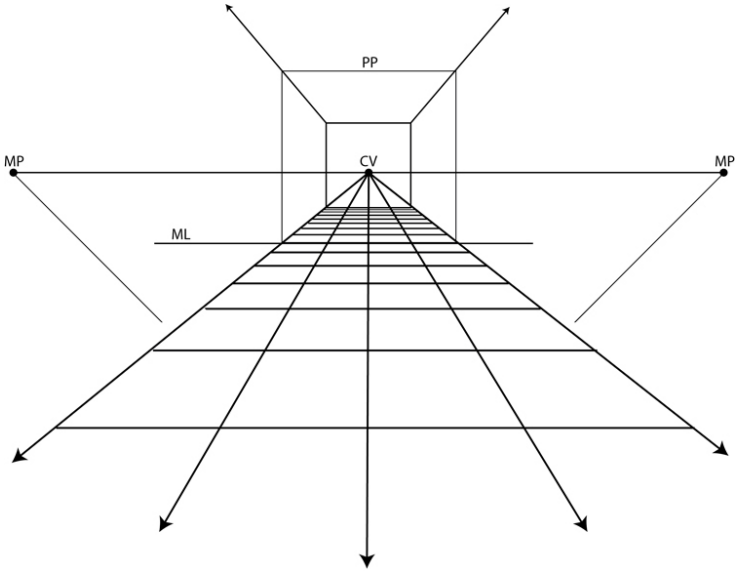


Figure 3.22 Placing a grid on the floor helps to visualize the space. **Return to text.**⏎ 37.

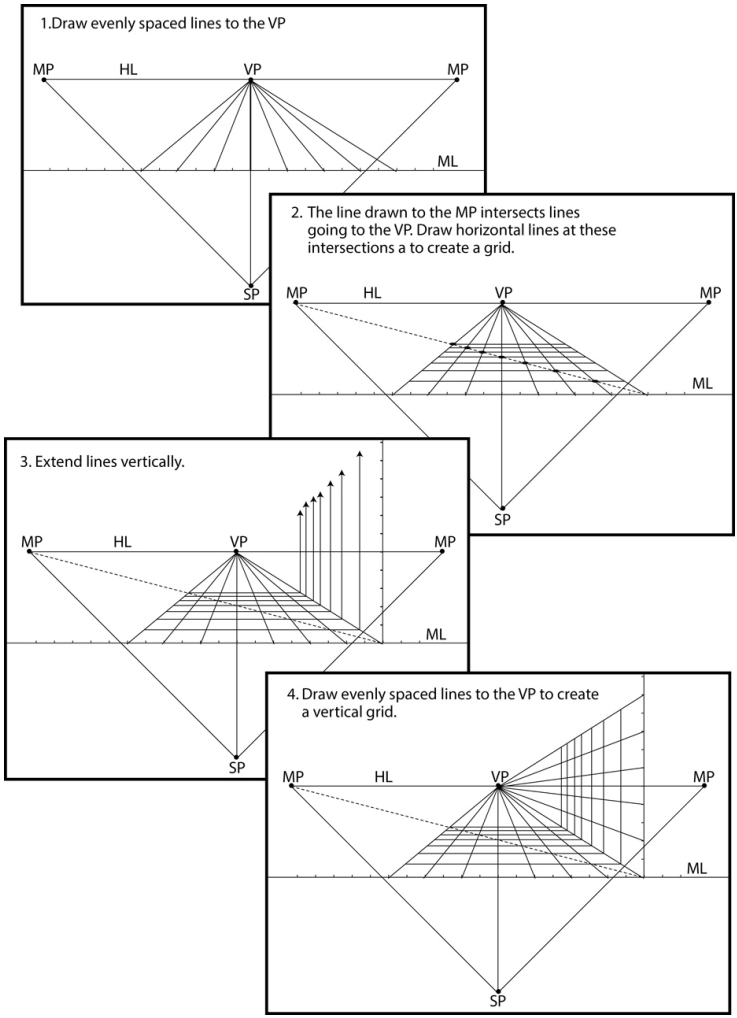


Figure 3.23 Follow these steps to create a one-point perspective grid. **Return to text.**⏎ 38. 39.

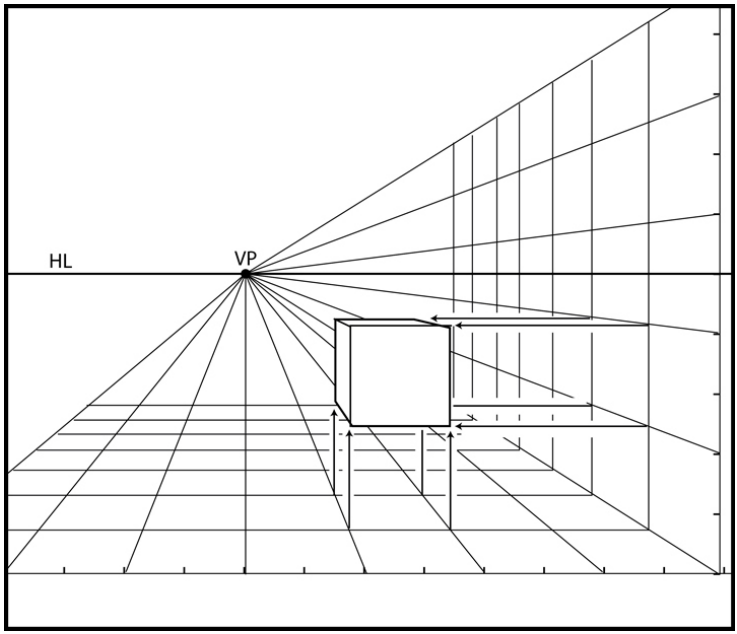


Figure 3.24 Using a grid to measure. **Return to text.**⏎ 40.

chapter 3
One-Point Perspective

DOI: 10.4324/9781003488101-5

24. Before a perspective drawing can be created, a perspective diagram needs to be constructed. The diagram is the foundation for the image, the basal element of perspective. It establishes the infrastructure and key elements necessary for accurate representation.

Creating a One-Point Perspective Diagram

Here is a list of the principal components of the diagram and how to arrange them.

Horizon Line

Begin by drawing a horizontal line. This line represents the horizon. It can be drawn anywhere, although it is usually best to place it somewhere in the center of the page. The horizon line is always at the viewer's eye level.

Station Point

The placement of the station point defines the distance from the viewer to the picture plane. The station point's location is in the third dimension—however, the paper has only two dimensions. This creates an obvious problem. This obstacle is circumvented by drawing the distance from the viewer to the picture plane vertically. The distance from the center of vision to the station point represents the distance from the viewer to the picture plane. Decide how far the viewer is from the picture plane (the greater the distance, the larger the cone of vision). Then, from the center of vision, draw a line down to the station point (the station point and the center of vision are always aligned). There is no foreshortening to this line (Figure 3.1). For example, if the distance from the viewer to the picture plane is drawn at 10 units, and the scale is 1:2, then the viewer is 20 units from the picture plane. It is usually a good idea to put the station point as far away as comfortable. The farther away it is, the larger the cone of vision will be, therefore allowing for a larger drawing area.

Cone of Vision

From the station point, project a 30° angle on each side of the line of sight. Then, centered on the focal point, draw a circle (Figure 3.2, right). Before beginning the drawing, it is prudent to establish the cone of vision. It's helpful to know the size of the image area at the outset.

Measuring Points

From the station point, project two 45° angles to the horizon

line (Figure 3.3). These are the measuring points. Lines drawn from either of these points create 45° angles in perspective. These points are used to measure foreshortened lines—lines drawn to the center of vision.

Measuring Line

Place the measuring line below the horizon. The measuring line is on the ground plane. The horizon line is at the viewer's eye level; therefore, the distance from the measuring line to the horizon line equals the distance from the ground to the viewer's eye. The lower the measuring line is drawn, the taller the viewer.

Divide the measuring line into units (Figure 3.4). Throughout this book, distances are referred to as units. A unit can represent any distance—one inch or one centimeter, ten miles or ten thousand meters.

The one-point perspective diagram is now complete, and the drawing can be started.

Measuring in One-Point Perspective

In one-point perspective objects are oriented to the picture plane in a specific way. Height and width are parallel to the picture plane, and depth is perpendicular to the picture plane. Each of these dimensions will be examined in turn.

Measuring Width

The line of sight is the direction the viewer is looking. Objects can be to the left or to the right of the line of sight. Measure this distance by counting units along the measuring line (Figure 3.5).

Measuring Depth

Lines that are 90° to the picture plane connect to the center of vision (Figure 3.6). These lines are foreshortened and can't be measured directly with a ruler. The process of measuring

foreshortened lines involves some simple geometry—no equations are required. The angle between opposing corners of a square is 45°. By drawing a 45° angle, a square can be drawn. The measuring point draws 45° angles in perspective. The measuring point transfers a horizontal distance to a foreshortened line. When measuring in one-point perspective, half a square is drawn—a right-angle isosceles triangle (Figure 3.7). See Chapter 6 for supplemental information on measuring.

Measuring Height

To measure vertically, turn the measuring line 90°. Using the same scale, measure up from the ground to the desired height (Figure 3.8). The height can be projected forward or backward using the center of vision.

Drawing a One-Point Perspective Box

Now height, width, and depth can be measured. These three skills can be combined to draw a box—a one-point perspective, right-angled cuboid.

Create the Diagram

First, draw the diagram. The dimensions used are random and can, of course, be any desired number. For this example, the viewer is 4.5 units from the picture plane, with an eye level 3 units above ground (Figure 3.9).

Place the Box

The box is 1 unit to the left of the center of vision and 2 units behind the picture plane (Figure 3.10).

Measure the Box

The box is 2 units wide, 3 units deep, and 2 units high. Measure each dimension one line at a time (Figures 3.11–14).

Complete the Box

Once the height, width, and depth have been measured, find the intersections of these lines to create the corners of the box. Vertical lines are perpendicular to the horizon line. Horizontal lines are parallel to the horizon line. Lines that recede in space connect to the center of vision (Figure 3.15).

34. Continue to practice. Try varying the dimensions or changing the viewer's eye level and distance to the picture plane. Draw several objects on one page. Become comfortable with one-point perspective before progressing to two-point.

Measuring in Front of the Picture Plane

The previous box was behind the picture plane (between the picture plane and the horizon line). Depth was measured by projecting backward from the measuring line (toward the measuring point) (Figure 3.16).

If an object is in front of the picture plane (between the picture plane and the viewer), measure depth by projecting forward (away from the measuring point) (Figure 3.17).

35. If an object is straddling the picture plane, depth is measured by projecting backward *and* forward from the measuring point (Figure 3.18).

This dynamic will be explored further with an example. Draw a room with the measuring line placed between the back wall and the viewer (the picture plane bisects the room) (Figure 3.19). Measurements behind the picture plane are projected backward, toward the measuring point (Figure 3.20). Measurements in front of the picture plane are projected forward, away from the measuring point. The room surrounds the viewer, so the complete room cannot be drawn. The front of the room is beyond the cone of vision, as well as beyond the edge of the page (Figure 3.21). Placing a grid on the floor may help to visualize the space. Each square represents a half unit, which leads to the next topic: grids (Figure 3.22).

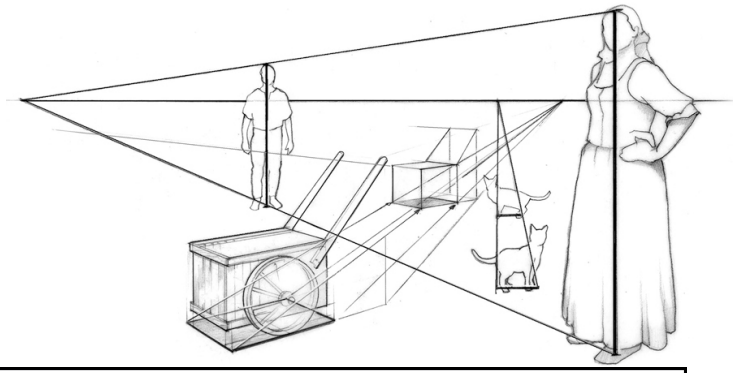
Drawing a One-Point Grid

Drawing a grid is a straightforward task. However, take care to not be overly dependent on grids. If perspective—and the geometry—is understood, then the grid is superfluous. Drawing without a grid is faster and more versatile, but it does have a steeper learning curve. A grid takes time to draw and is awkward for depicting objects that do not conform its pattern. However, grids—once they are established—conveniently guide the direction of lines and assist in establishing dimensions. Learning the grid system can be a good starting point for those new to perspective, and there are some instances where establishing a grid is the best solution to a problem.

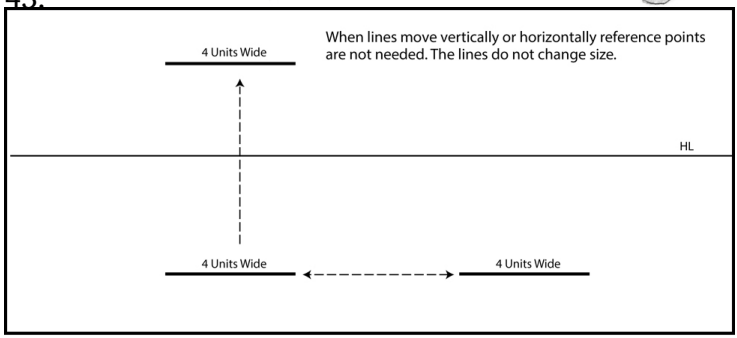
Drawing a grid involves creating a series of squares. The size of each square, and the number of squares created, are determined by the image. More detailed drawings suggest a smaller, tighter grid. Because of the superabundance of lines, grids are usually used as an underlay. Each square represents one unit of measurement (Figure 3.23). A horizontal grid is used to measure width and depth, and a vertical grid is used to measure height (Figure 3.24).

41. 42.

part three
Reference Points



43.



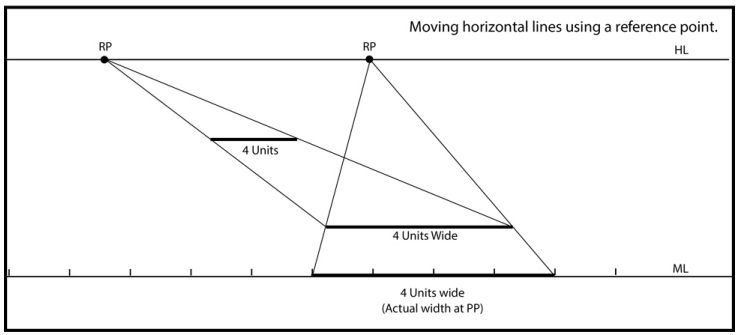
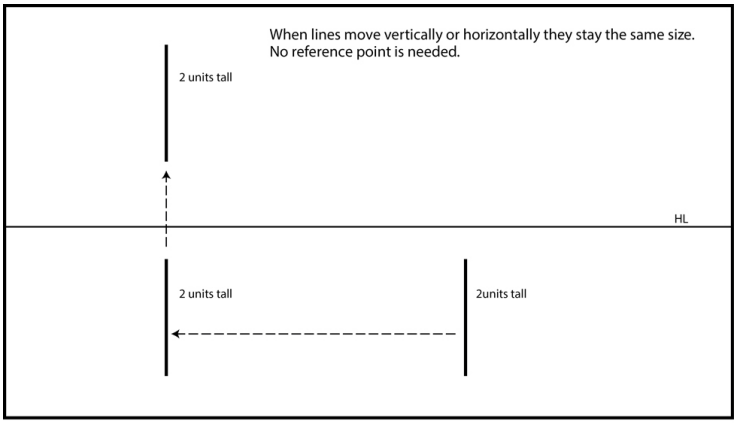


Figure 4.1 Reference points are not needed when moving lines from side to side or up and down (top). Use reference points to move lines forward or backward in space. The lines being moved must be parallel to each other and on the same horizontal plane (bottom). **Return to text.**⏎



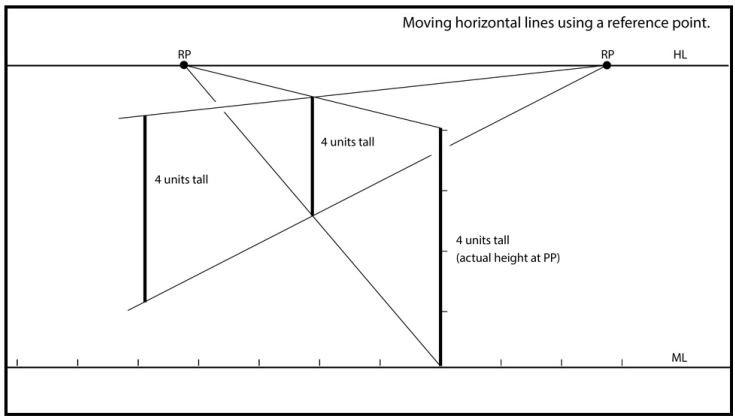


Figure 4.2 Use reference points to move vertical lines. The lines being moved must be parallel to each other and on the same horizontal plane. **Return to text.**⏎ 45.

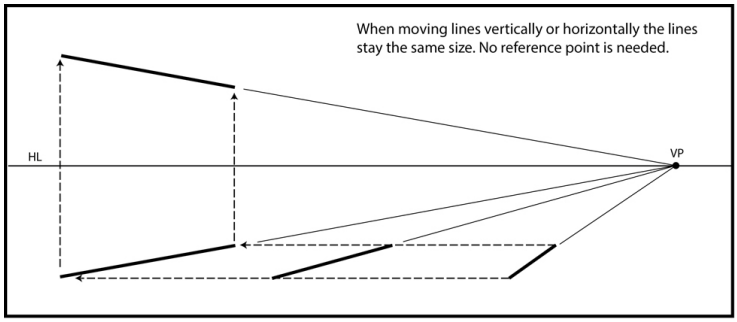


Figure 4.3 Use reference points to move foreshortened lines. The lines moved must remain parallel to each other (connect to the same vanishing point) and be on the same horizontal plane. **Return to text.**⏎

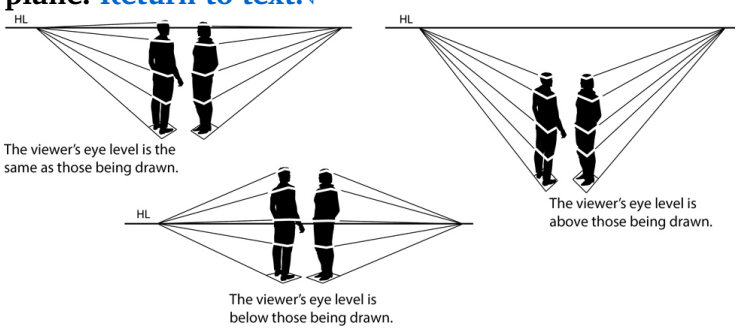


Figure 4.4 Reference points are useful tools to move figures forward and backward in space while retaining proper scale. Equally important is to draw the figures so their shapes conform to the viewer's eye level. **Return to text.**⏎

chapter 4
Reference Points

DOI: 10.4324/9781003488101-7

44. Reference points are not needed to move lines up, down, or from side to side. Lines moving in any of these directions do not change size (Figures 4.1–3, top). Reference points are only used to move lines forward or backward in space (Figures 4.1–3, bottom).

46. 47. Keep in mind the lines used in this chapter (and the shapes represented in every chapter) are placeholders for real objects. The lines can represent the length of a building, the width of a car, the height of a person, and so on. Reference points are a way to maintain proper scale between objects and are especially useful for drawing figures. When drawing figures in perspective it is important to maintain proper scale as well as placing the figure in the correct orientation to the viewer's eye level (this of course applies to drawing anything in perspective). When placing the figure in an environment the angles of the shoulders, hips, and feet must be correctly oriented to the ground plane and the viewer's eye level (Figure 4.4). Figure drawing is a specialized skill that involves an understanding of human proportions, anatomy, and cloth folds and lots of practice. These skills are critical to drawing convincing figures and are beyond the scope of this book.

49. 50.

part four
Two-Point

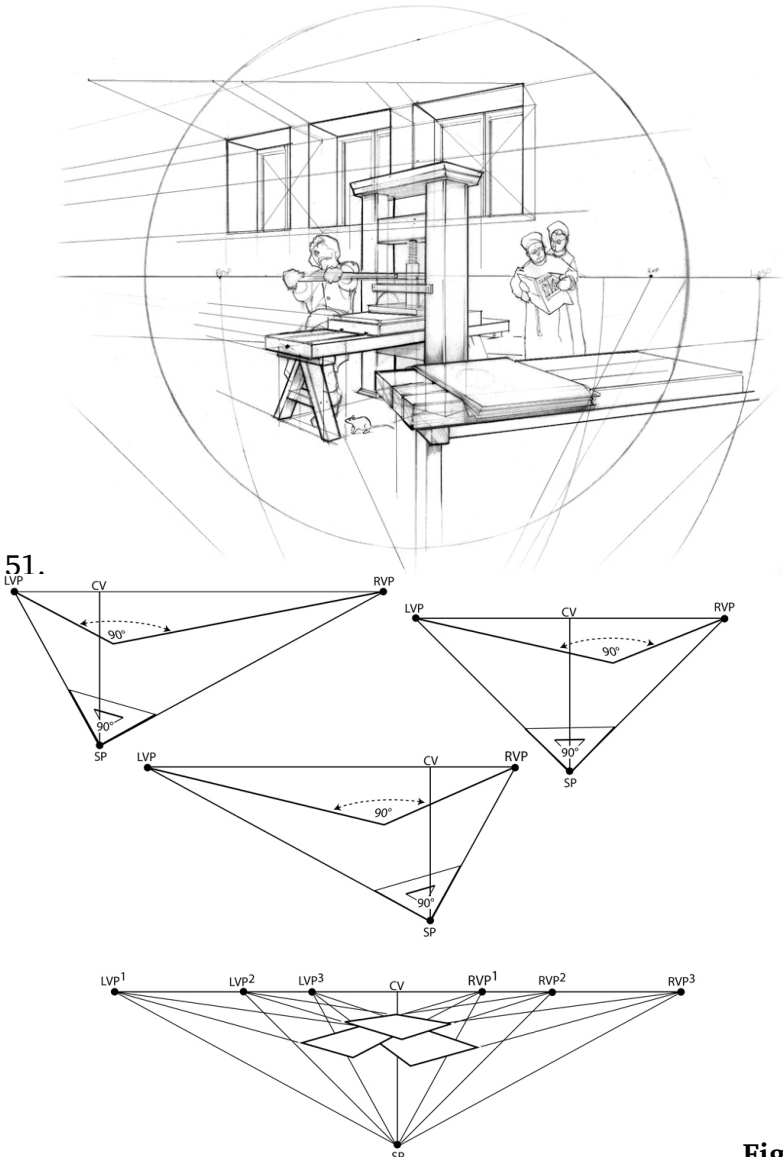


Figure 5.1 True angles are found at the station point. A true 90° angle drawn from the station point creates left and right vanishing points that draw 90° angles in perspective. There can be as many pairs of vanishing points as there are objects. **Return to text.**⏎

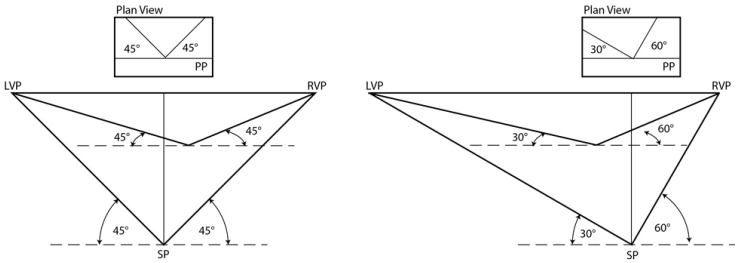


Figure 5.2 Use the station point to draw objects at specific angles. The left example shows the object turned 45° to the picture plane. The right example shows the object turned 30°/60° to the picture plane. Any angle can be created by projecting it from the station point to the horizon line. **Return to text.**

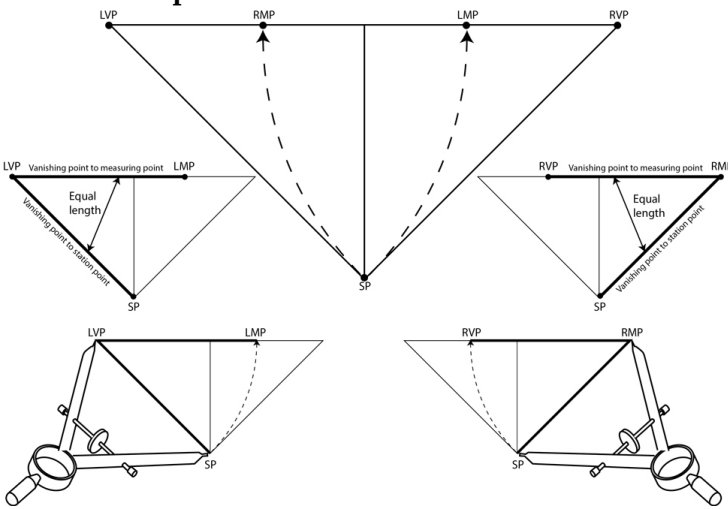
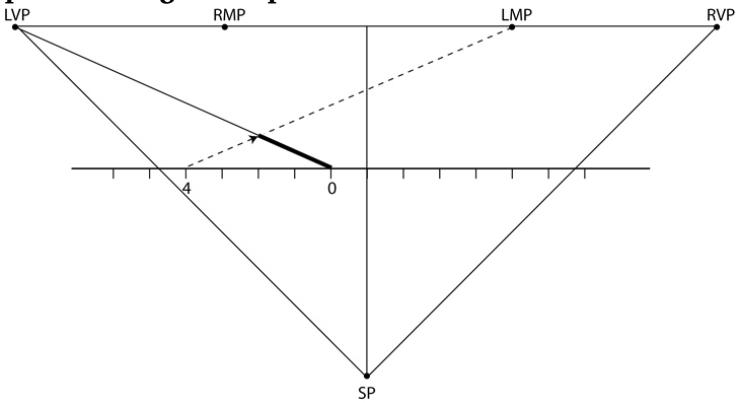


Figure 5.3 Plot the location of the left and right measuring points using a compass or a ruler. **Return to text.** 54.



Figure

5.4 Use the left measuring point to measure lines that connect to the left vanishing point. **Return to text.**⏎ 55.

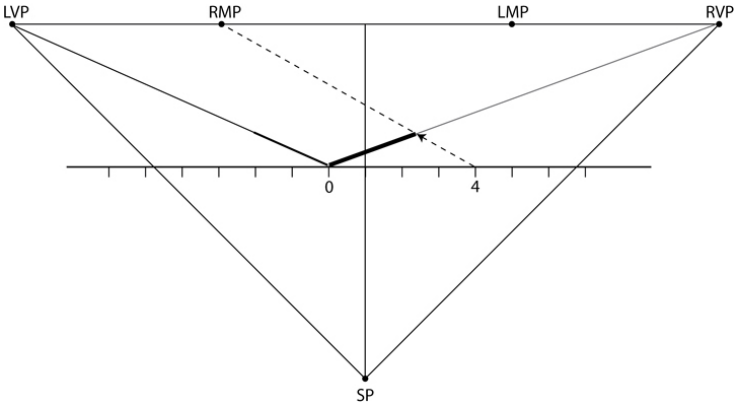


Figure 5.5 Use the right measuring point to measure lines that connect to the right vanishing point. **Return to text.**⏎

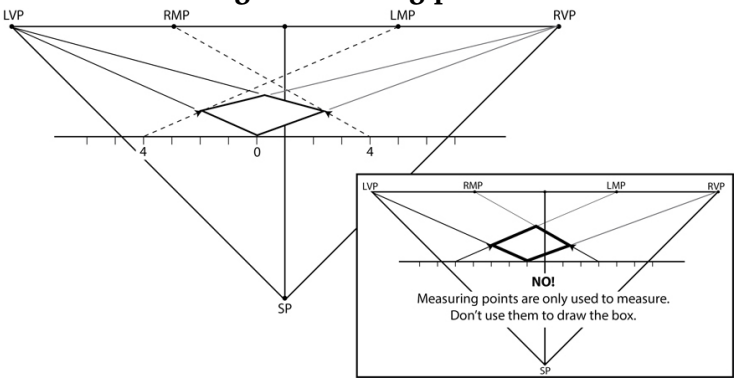


Figure 5.6 The back of the box connects to vanishing points. A common mistake is to use a measuring point where a vanishing point should be used. **Return to text.**⏎ 56.

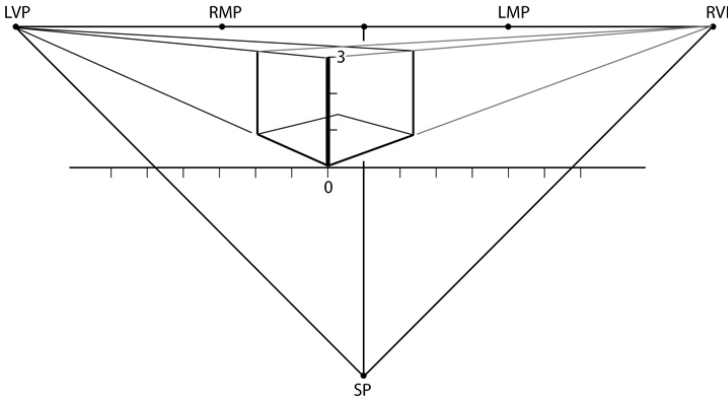


Figure 5.7 Measure vertical dimensions at the picture plane. **Return to text.**⏎ 57.

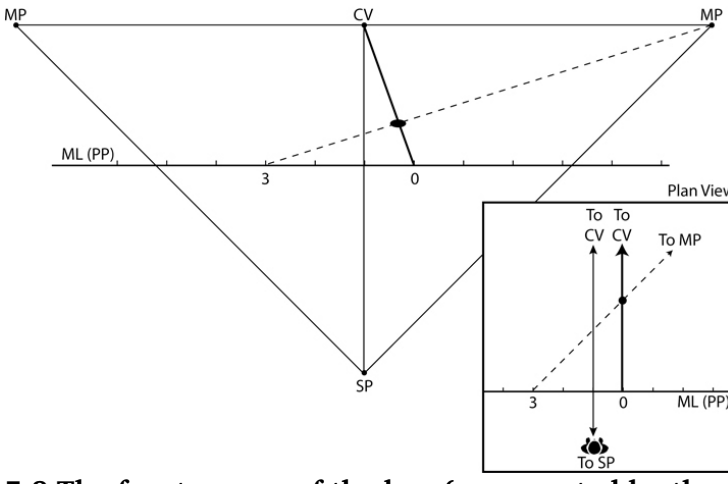


Figure 5.8 The front corner of the box (represented by the dot) is 1 unit to the right of the center of vision and 3 units behind the measuring line. **Return to text.**⏎

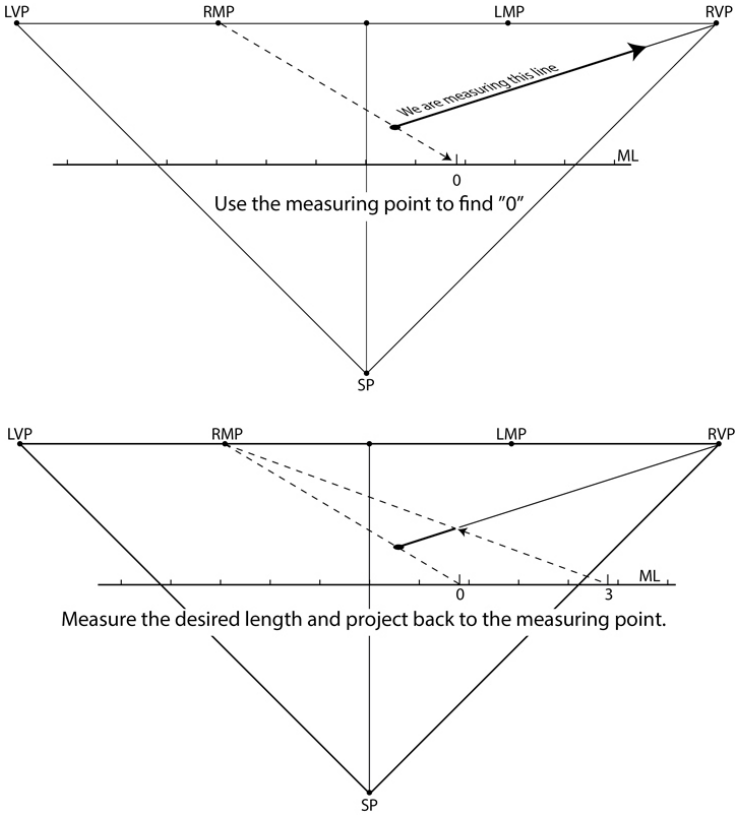


Figure 5.9 The right measuring point is used to measure lines connecting to the right vanishing point. **Return to text.**⏎

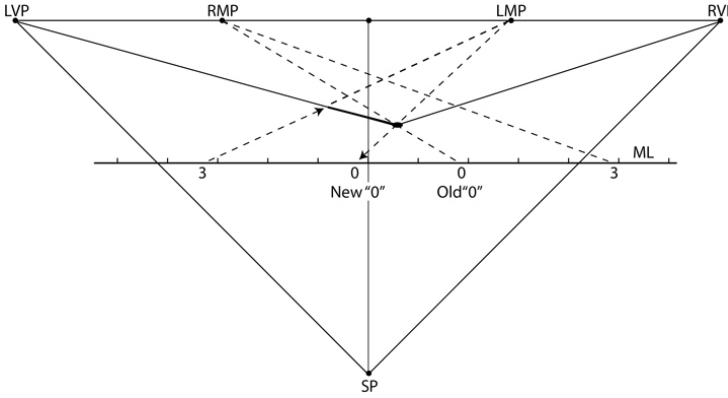


Figure 5.10 Measure the left side by finding a new zero point. Measure the desired distance and project back to the left measuring point. **Return to text.**⏎

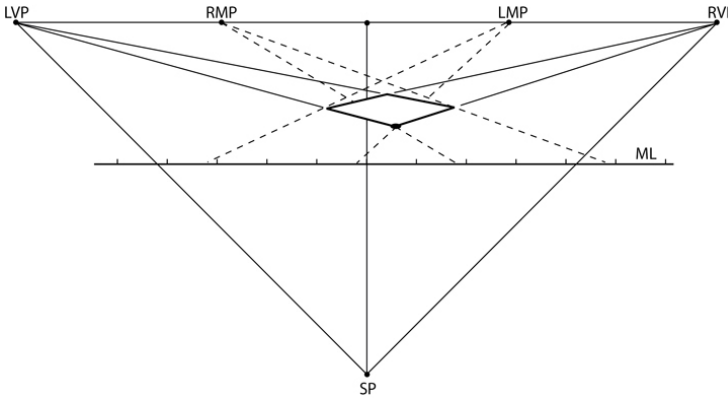


Figure 5.11 Connect to vanishing points to complete the square. **Return to text.**⏎ 60.

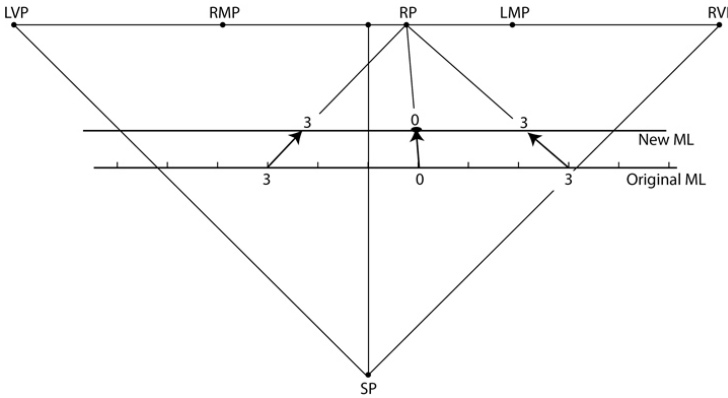


Figure 5.12 Use a reference point to move the measuring line. **Return to text.**⏎

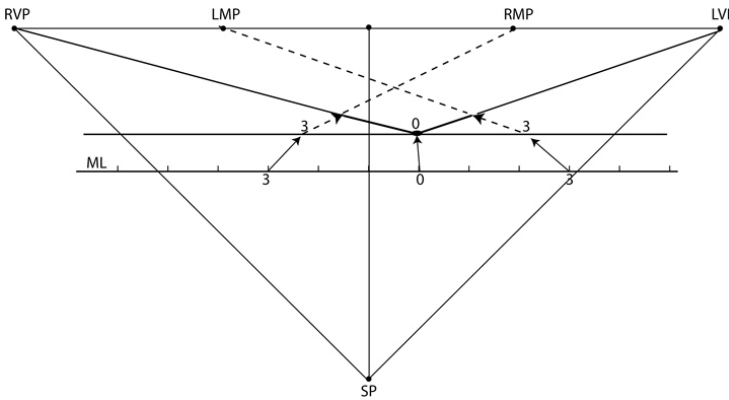


Figure 5.13 With the measuring line relocated, measure the respective lines using the proper measuring points. **Return**

to text.⏎ 61.

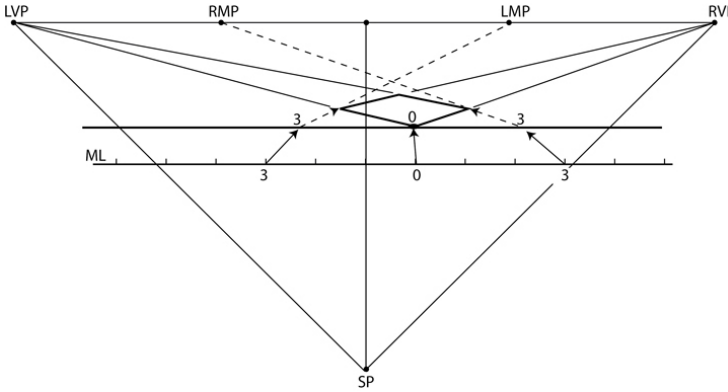


Figure 5.14 Connect lines to vanishing points to create the back of the square. Return to text.⏎

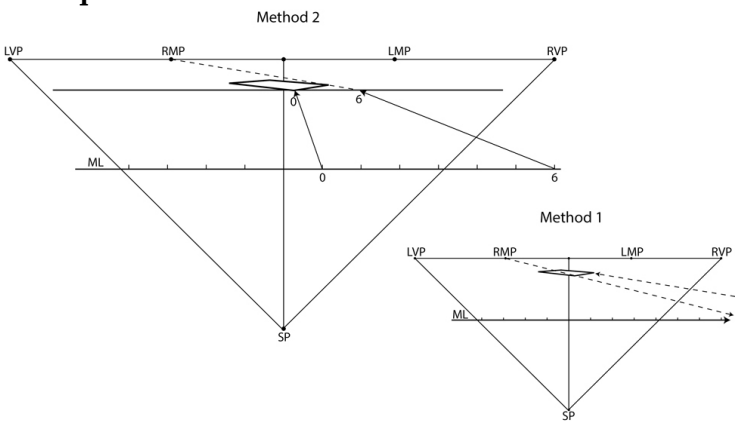


Figure 5.15Moving the measuring line (Method 2) keeps measurements from exceeding the bounds of the paper (as compared to Method 1). Return to text.⏎ 62.

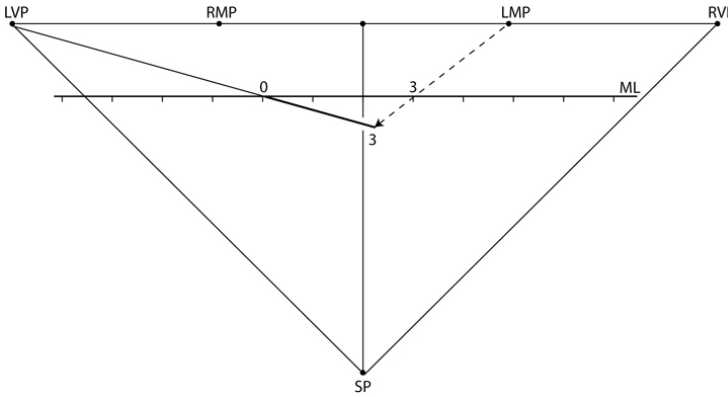
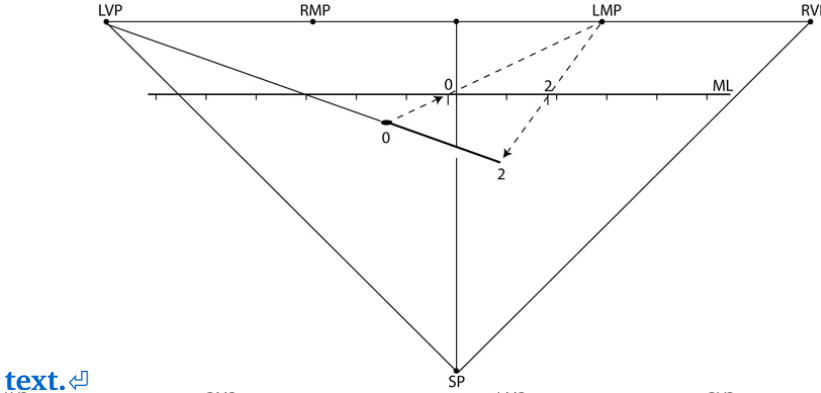


Figure 5.16 Measuring in front of the picture plane. **Return to text.**



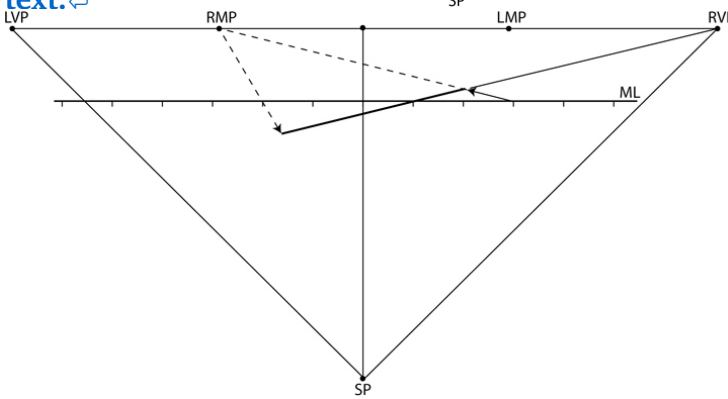


Figure 5.18 This line is 3 units in front and 2 units behind the picture plane. **Return to text.** 64.

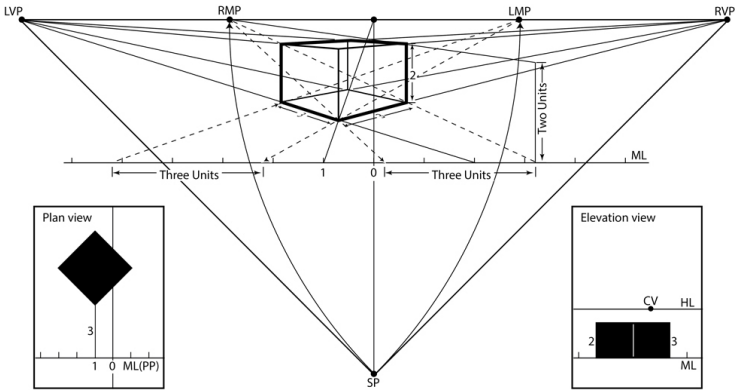


Figure 5.19 The completed box with construction lines intact.

Return to text.⏎

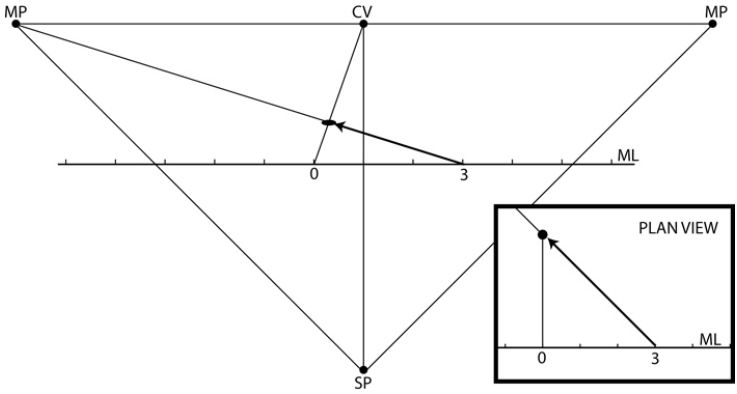


Figure 5.20 The location of the box's front corner is 1 unit to the left and 3 units behind the measuring line. **Return to text.**⏎

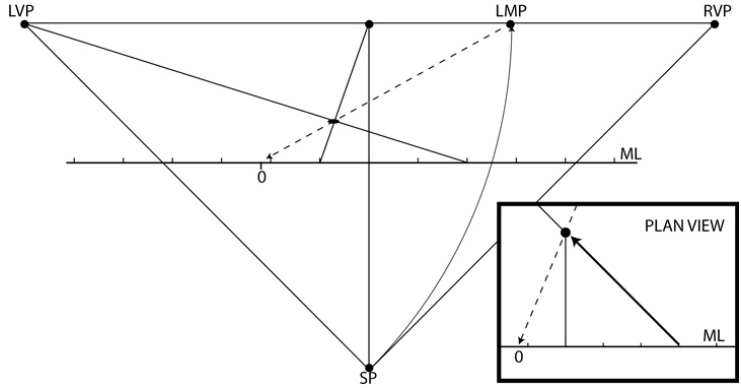


Figure 5.21 Finding the zero point. **Return to text.**⏎

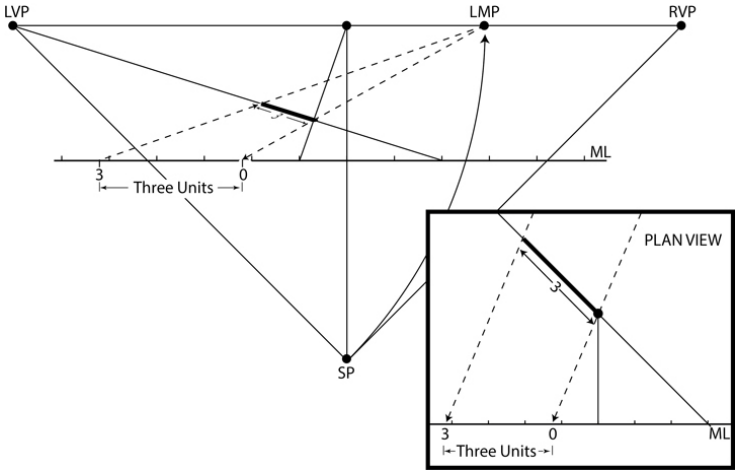


Figure 5.22 Measuring the left side of the box. **Return to text.**⏎ 66.

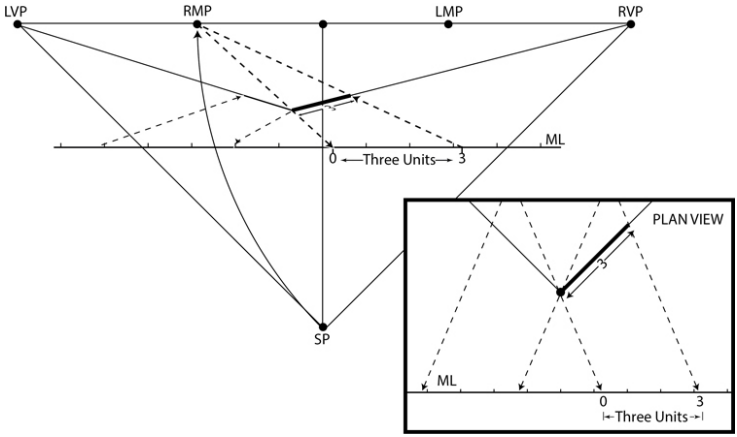


Figure 5.23 Measuring the right side of the box. **Return to text.**⏎

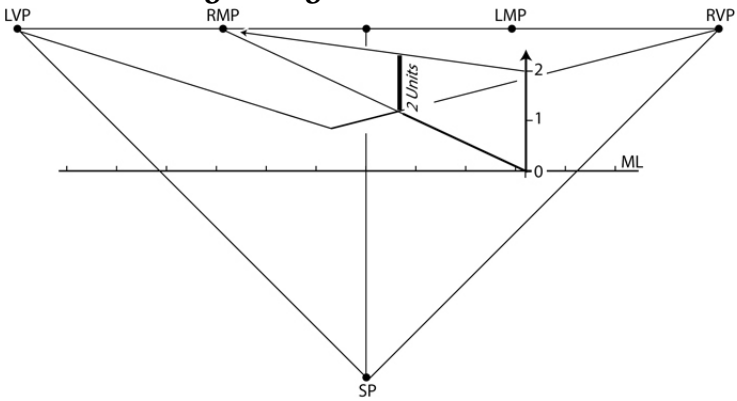


Figure 5.24 Using the right measuring point as a reference point to

measure height. Return to text. 67.

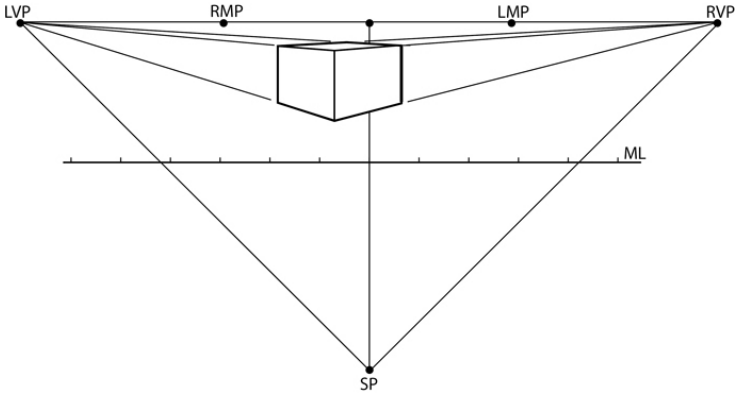


Figure 5.25 Connect lines to vanishing points to complete the box. Return to text.

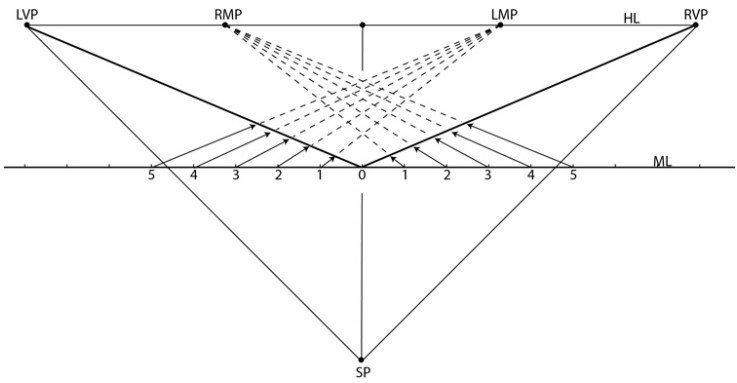


Figure 5.26 Measure evenly spaced segments along the lines connecting to the vanishing points. Return to text. 68.

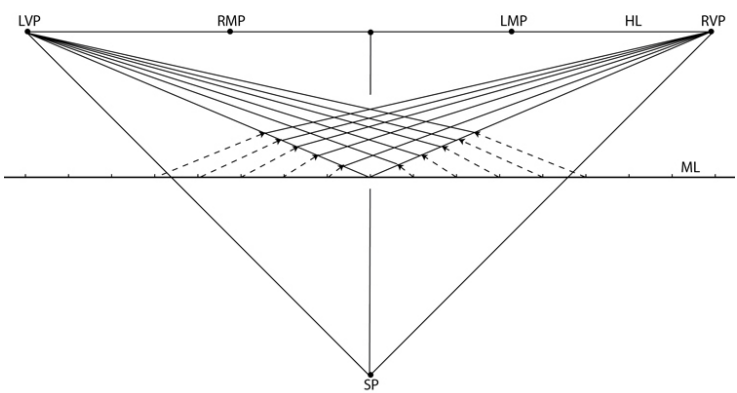


Figure 5.27 Connect the measurements to vanishing points to

create a grid. Return to text.⏎ 69.

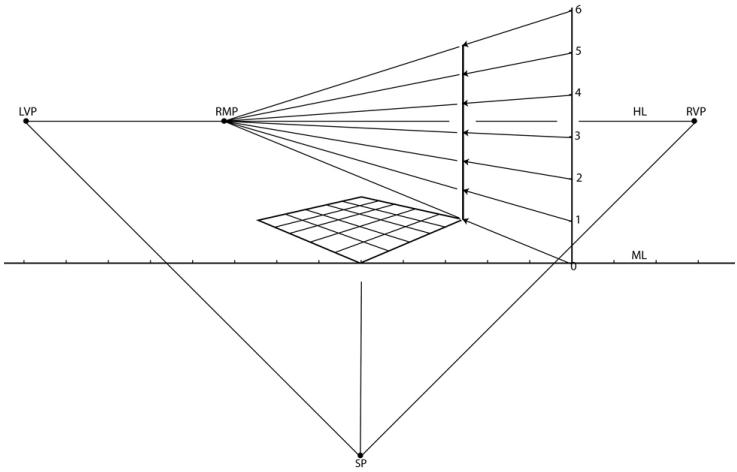


Figure 5.28 Create a vertical grid by transferring dimensions from the picture plane. The right measuring point is functioning as a reference point. Return to text.⏎

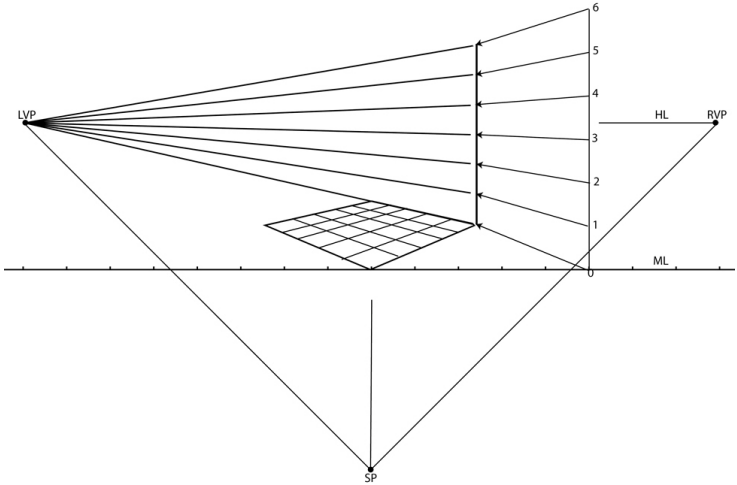


Figure 5.29 Connect vertical segments to the vanishing point. Return to text.⏎ 70.

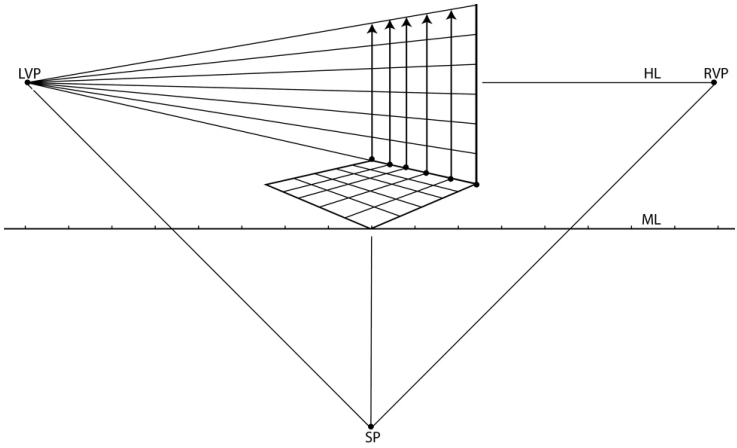


Figure 5.30 Project vertical lines from the horizontal grid to complete the squares. **Return to text.**⏎ 71.

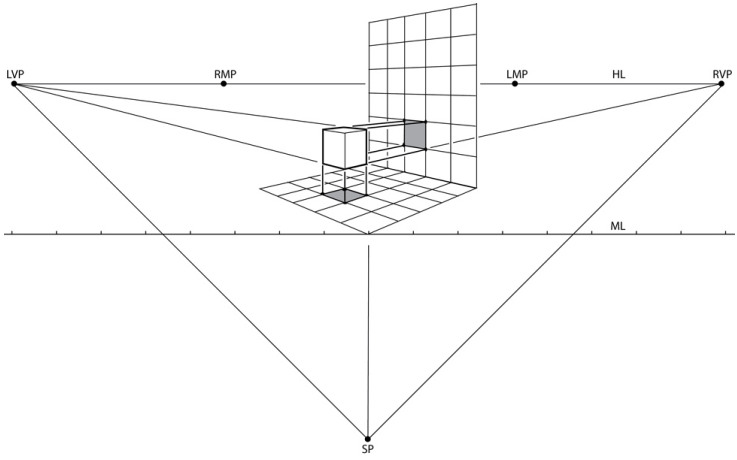


Figure 5.31 Use the grid to measure objects. This cube is 1 unit from the front left wall, 2 units from the front right wall, and 1 unit above the ground. **Return to text.**⏎

chapter 5
Two-Point Perspective

DOI: 10.4324/9781003488101-9

52. When an object is viewed at an angle, when only the vertical dimension is parallel to the picture plane, and when both width and depth are foreshortened, the object is in two-point perspective. Predictably, two-point perspective has two vanishing points, a left vanishing point and a right vanishing point. The location of the vanishing point depends on the angle of the object being drawn.

Two-Point Perspective Diagram

Vanishing Points

Most objects have 90° corners. To create 90° corners in perspective, the left and right vanishing points must be 90° apart (subsequent chapters will discuss how to create other angles).

Using a triangle, place a true 90° angle at the station point, then, project that angle to the horizon line. The resulting points (the right and left vanishing points) will draw 90° angles in perspective. Any 90° angle projected from the station point creates two vanishing points that draw that same angle in perspective (Figure 5.1).

53. Understanding perspective is to understand angles. The station point is a powerful tool. Angles placed at the station point mirror the perspective angles in the drawing. To draw an object at a specific angle to the picture plane, draw that angle from the station point to the horizon line; the vanishing points created will draw those same angles in perspective (Figure 5.2). Multiple objects at various angles can be created using this technique, as discussed further in Chapter 7 (Figure 7.2).

Measuring Points

Each vanishing point has a dedicated measuring point. The left vanishing point has a left measuring point (LMP), and the right vanishing point has a right measuring point (RMP). The left measuring point measures lines connecting to the left vanishing point. The right measuring point measures lines connecting to

the right vanishing point.

The placement of measuring points is specific. The distance from the measuring point to the vanishing point is the same as the distance from the station point to the vanishing point. There are two ways to find the correct placement of the measuring point, using a compass or a ruler. When using a compass, put the stationary arm of the compass on the vanishing point and draw an arch from the station point to the horizon line. The same result can be achieved using a ruler (Figure 5.3).

Measuring Depth

Measuring in two-point perspective follows the same procedures as one-point. It is, however, a little more complicated, as there are now two measuring points. The more points there are on the horizon line, the harder it is to keep track of them. Color-coding the perspective layout keeps mistakes to a minimum. For example, label lines from the right vanishing point and right measuring point in one color, and label lines from the left vanishing point and left measuring point in another.

Use the left measuring point to measure lines connecting to the left vanishing point (Figure 5.4). Use the right measuring point to measure lines connecting to the right vanishing point (Figure 5.5).

Completing the Shape

After measuring the left and right side, complete the shape by connecting the corners to vanishing points. Take care to connect the lines to *vanishing points*. Do not connect lines to measuring points. Measuring points are only for measuring; they are not part of the physical object. Lines connecting to measuring points are phantom lines; they are invisible. This mistake can usually be spotted quickly, as the shape's corners will not look square (Figure 5.6).

Measuring Height

Measuring vertical dimensions in two-point perspective is no

different than one-point perspective. Vertical lines touching the picture plane are actual size. Project the height to the desired location using a vanishing point or a reference point (Figure 5.7).

More Two-Point Measuring

In the previous example, the front of the box was touching the picture plane. This creates a convenient situation for measuring. The zero point was where the box contacts the measuring line. To measure depth, it was a case of simply counting to the left and right of zero. But what if the box does not touch the measuring line? How is this measured, and where is the zero point? Where does the counting begin? Before discussing the solutions, draw a sample square that does not touch the picture plane.

Location

Place the square 1 unit to the right of the center of vision and 3 units behind the picture plane. Use one-point perspective to find this location (Figure 5.8). Refer to Chapter 3, Figures 3.9–10 for additional information about measuring in one-point perspective.

Measuring Behind the Picture Plane

There are two solutions to measure shapes not touching the measuring line: 1) project the object to the measuring line, or 2) move the measuring line to the object.

Method 1: Project the Object to the Measuring Line

To measure an object, a point is needed to begin measurements —a zero point. To find the zero point, project the line being measured to the measuring line. How it is projected is critical; there is specific geometry to adhere to. The appropriate measuring 58. point must be used to find the length of a foreshortened line. To find the zero point for lines drawn to the

right or left vanishing point, use the right or left measuring point, respectively. Use the right measuring point to measure lines connecting to the right vanishing point (Figure 5.9), and use the left measuring point to measure lines connecting to the left vanishing point (Figure 5.10).

59. Project the beginning of the line to the picture plane. This is the zero point. Count the desired distance along the measuring line, and then project back to the same measuring point.

Connect the lines to vanishing points to complete the square (Figure 5.11).

Method 2: Move the Measuring Line to the Object

An alternative method is to move the measuring line. Position it so that it touches the object being measured. The measuring line must be moved in perspective, using a reference point (Figure 5.12). Once the new measuring line is in place, follow the procedures outlined in Figures 5.4–6.

Distant Objects

If the object being measured is located a great distance from the picture plane, using Method 1 can be inconvenient. In these situations, Method 1 would require a very long ruler. The second method, moving the measuring line back and creating smaller units closer to the object being measured, is the preferred method (Figure 5.13–15).

Measuring in Front of the Picture Plane

Measuring lines in front of the picture plane follows the same basic procedures as measuring lines behind the picture plane. The difference is lines are projected forward from the measuring line instead of backward (Figure 5.16).

63. If the line being measured does not touch the picture plane, use the measuring point to project the measurements forward (Figure 5.17).

If a line straddles the picture plane, it requires a combination

of projecting measurements backward and forward (Figure 5.18).

Drawing a Two-Point Box

Now that the basics of two-point perspective have been covered, it is time to apply this information to a drawing. This example is a box, 2 units tall, 3 units wide, and 3 units deep. It is 1 unit to the left of the center of vision and 3 units behind the picture plane (Figure 5.19 shows how the finished layout will look). To approach this problem, do one step at a time.

Location

First, using one-point perspective, measure 1 unit to the left of the center of vision, then 3 units behind the picture plane (Figure 5.20).

Left Side

First find the zero point. Using the left measuring point, project the front corner of the box (represented by the dot) to the measuring line (Figure 5.21). Measure 3 units to the left, and then project back to the left measuring point (Figure 5.22).

Right Side

Use the same procedure to measure the right side. But first, find a new zero using the right measuring point (Figure 5.23).

Height

Height is not foreshortened. A reference point can be used to establish the height. A reference point can be any dot on the horizon line (Figure 5.24 uses the right measuring point).

Completing the Box

To complete the box, connect the horizontal lines to the vanishing points, and draw the vertical lines parallel to the

picture plane (Figure 5.25).

Two-Point Perspective Grid

As with one-point, a two-point perspective grid, once established, is an easy way to measure shapes and determine the proper direction of lines. But once confidence with perspective techniques has been achieved, grids become unnecessary. They take undue time to create, and they make drawing objects at angles other than the grid angles awkward. Despite its drawbacks, the grid's simplicity is enticing, and there are situations where establishing a grid can be the best solution to a problem.

Diagram

To draw a grid, first construct the diagram (establish the horizon line, station point, vanishing points, measuring points, and measuring line). Decide on the placement of the grid (the front corner is typically placed on the measuring line, aligned with the center of vision). Draw lines to the left and right vanishing points. Then, using the appropriate measuring point, divide these lines into equal increments. The number of increments made depends on the desired size of the grid (Figure 5.26).

Horizontal Grid

After measuring the grid segments, connect these measurements to vanishing points (Figure 5.27).

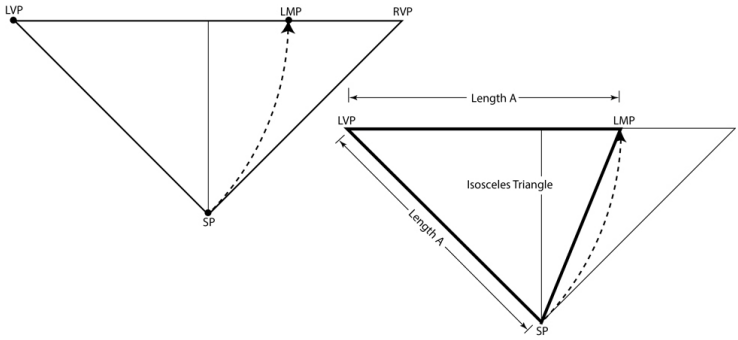
Vertical Grid

Use a reference point to project the vertical dimensions from the picture plane (Figure 5.28). Project each segment to the vanishing point (Figure 5.29). Extend the horizontal grid lines vertically to finalize the grid (Figure 5.30). Create a grid on the left wall if needed.

Completing the Grid

Once the grid is complete, it is typically used as an underlay to guide drawing. Each square represents 1 unit. Using this as a guide, a shape of any size can be made by counting squares and conforming the lines to the grid.

Use the horizontal grid to determine the width, depth, and placement of the shape being drawn. Use the vertical grid to determine height (Figure 5.31).



72.
Figure 6.1 The distance from the left vanishing point to the left measuring point is the same as the distance from the left vanishing point to the station point, an isosceles triangle. **Return to text.**⏎

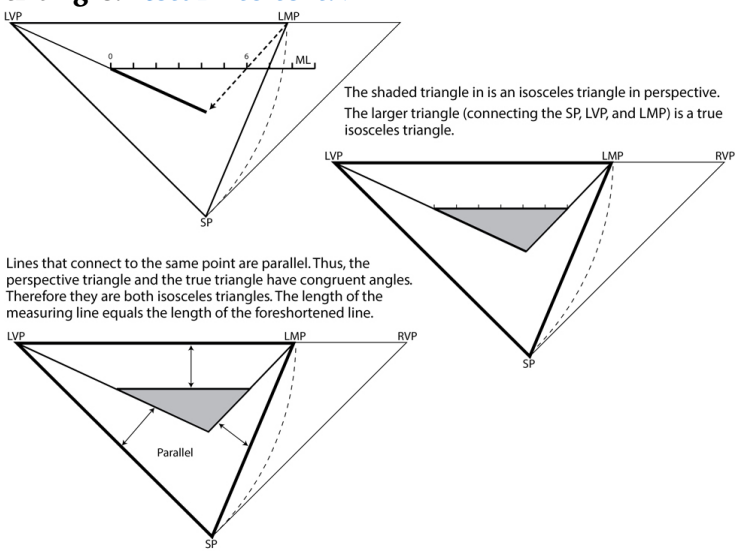


Figure 6.2 When using a measuring point, a foreshortened isosceles triangle is created. **Return to text.**⏎

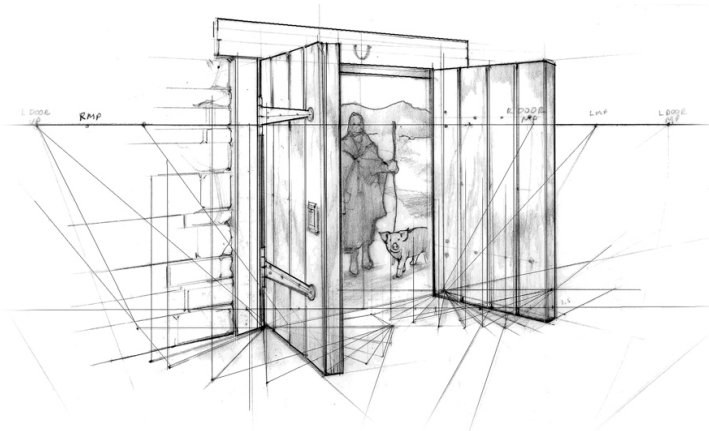
chapter 6
Measuring Point Geometry

DOI: 10.4324/9781003488101-10

73. Being well versed in geometry is not required in order to draw in perspective. But understanding why these methods are used helps remove the mystery and confusion that surrounds the process. To understand why measuring points work, isosceles triangles need to be understood. Isosceles triangles have two sides (legs) that are equal in length. When creating a measuring point, an isosceles triangle is created (Figure 6.1).

Connecting the vanishing point, station point, and measuring point creates a true isosceles triangle (Figure 6.1, right).

74. Lines drawn from the measuring point draw foreshortened isosceles triangles. The measuring line is always parallel to the picture plane; it is never foreshortened. When measuring, the length is transferred from the measuring line to a foreshortened line. The measuring line and the foreshortened line are the legs of the isosceles triangle. For the two legs of the triangle to be the same length, the angle created by the measuring point must be specific (Figure 6.2). It is therefore critical to use the proper measuring point. Otherwise, the shape drawn would not be an isosceles triangle; the two legs would not be the same, and the measurements would be inaccurate.



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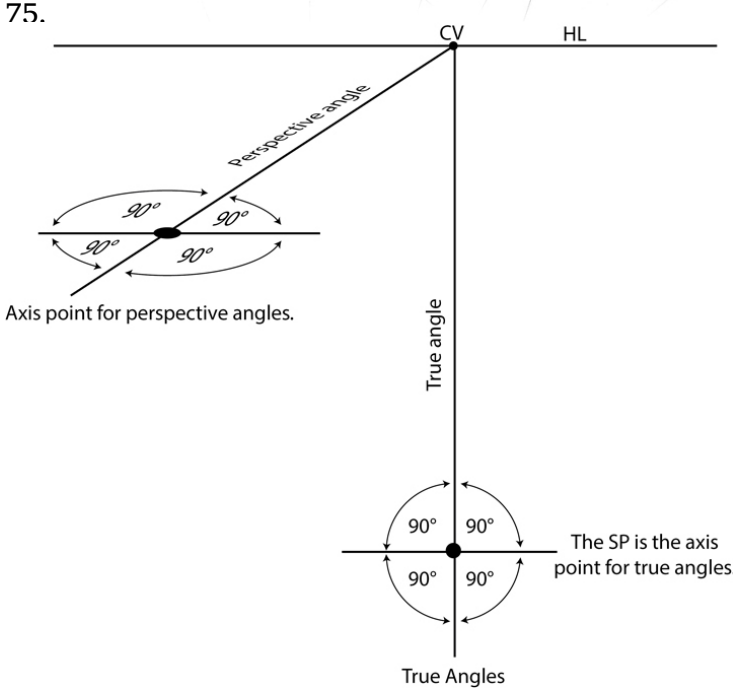
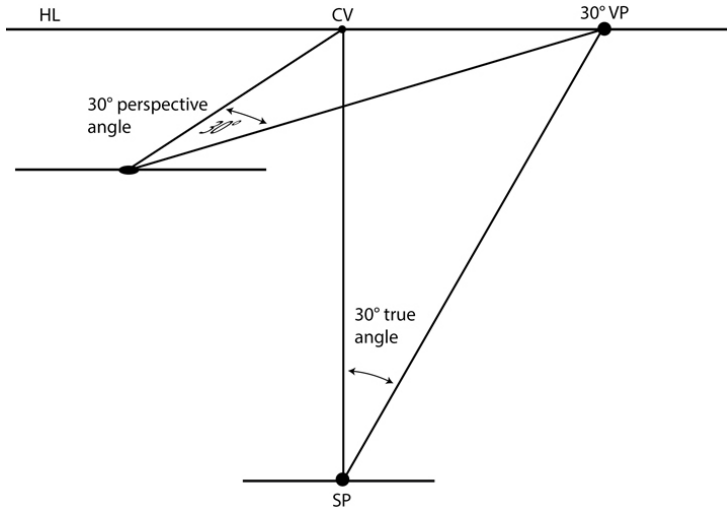


Figure 7.1 True 360˚ angles shown at the station point and 360˚ angles shown in perspective to the upper left. **Return to**



text.↵

Figure 7.2 True angles projected from the station point create vanishing points that draw that same angle in perspective. **Return to text.**↵ 77.

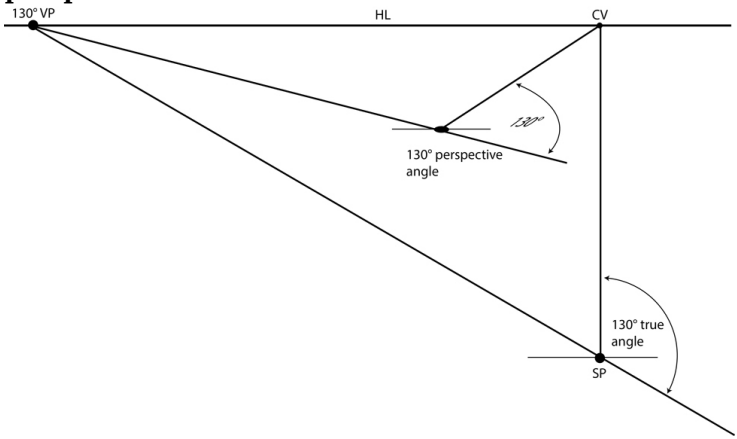


Figure 7.3 Angles can radiate from any direction around the station point, as there are 360°. **Return to text.**↵ 78.

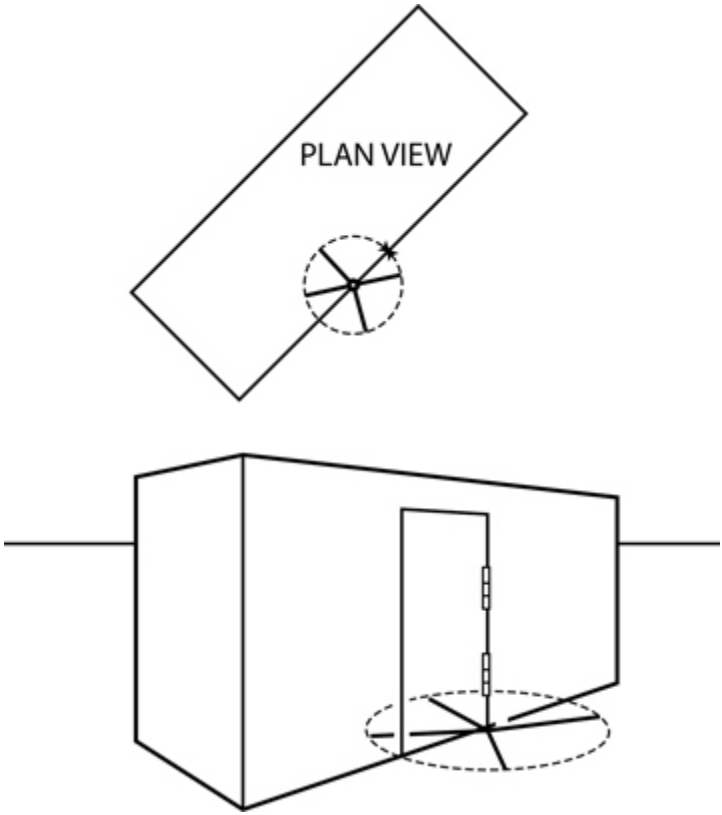


Figure 7.4 It is possible to open a door in or out, which makes it a convenient example to explore angles other than 90˚.
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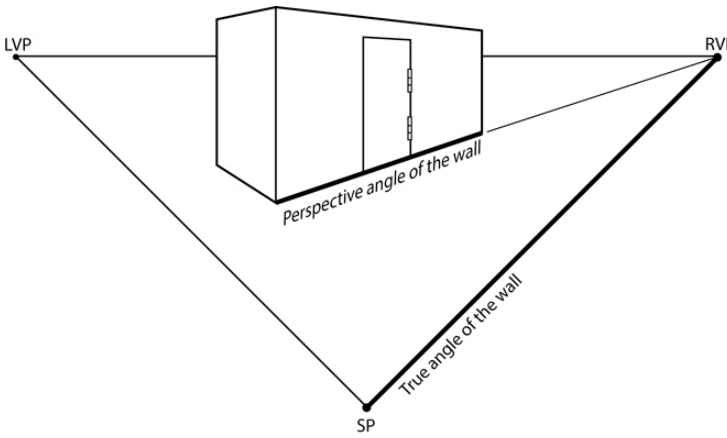


Figure 7.5 True angles of any foreshortened line can be found at

the station point. Return to text.

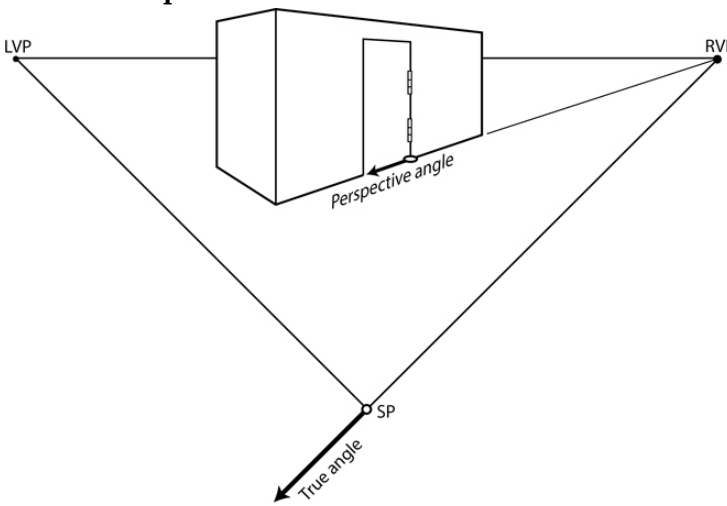


Figure 7.6 Angles at the station point reflect the true angles of perspective lines. Return to text. 79.

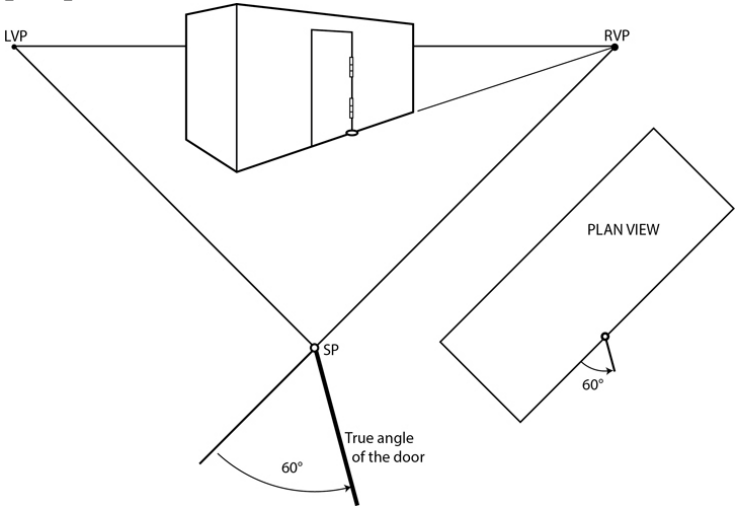


Figure 7.7 Draw the true angle of the door at the station point. The angles at the station point are the same as those in a plan view. They are both true angles. Return to text.

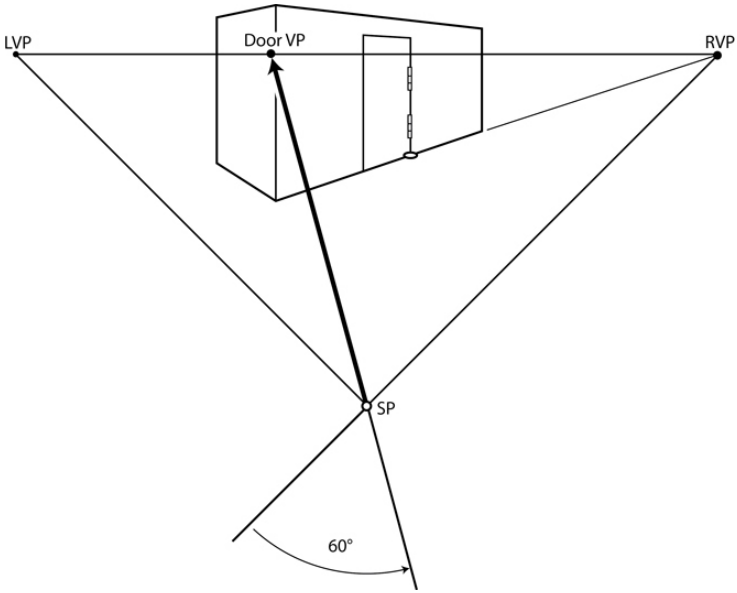


Figure 7.8 Project the true angle of the door to the horizon line creating a vanishing point that draws that same angle in perspective. **Return to text.**⏎ 80.

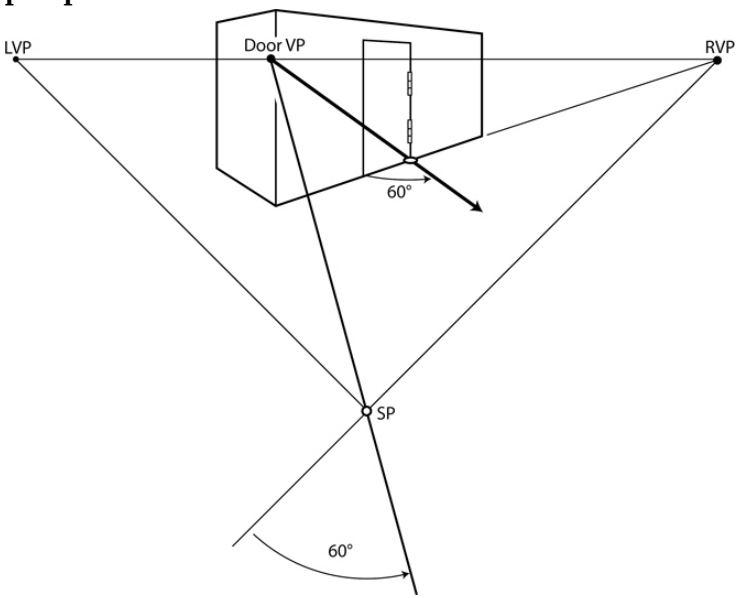
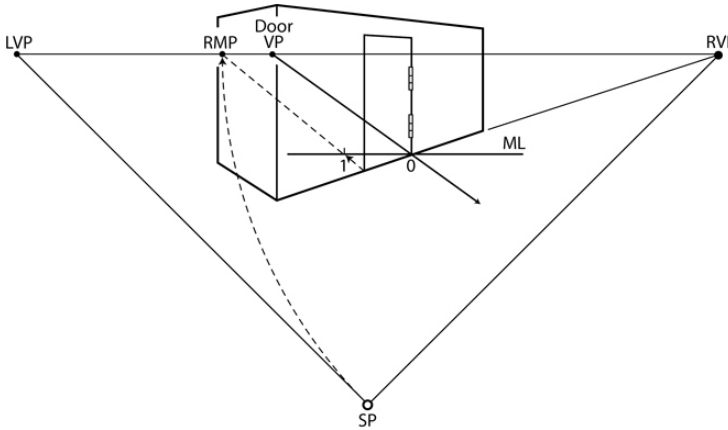


Figure 7.9 Lines drawn from the door vanishing point are 60° from lines drawn to the right vanishing point. **Return to text.**⏎



81.

Figure 7.10 Use the right measuring point to measure the door's threshold. Return to text.⏎

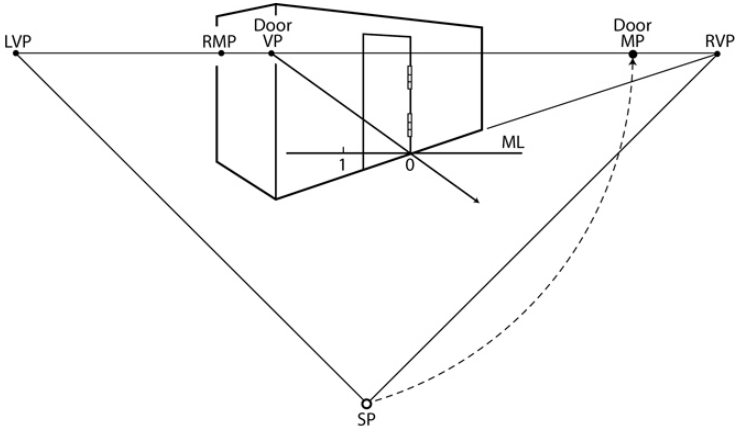
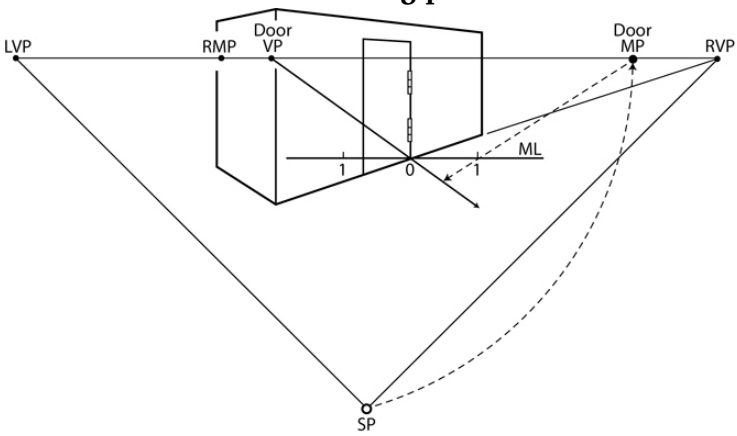


Figure 7.11 Create a door measuring point. Return to text.⏎ 82.



Figure

7.12 Use the right measuring point to measure the door's threshold. **Return to text.**↵

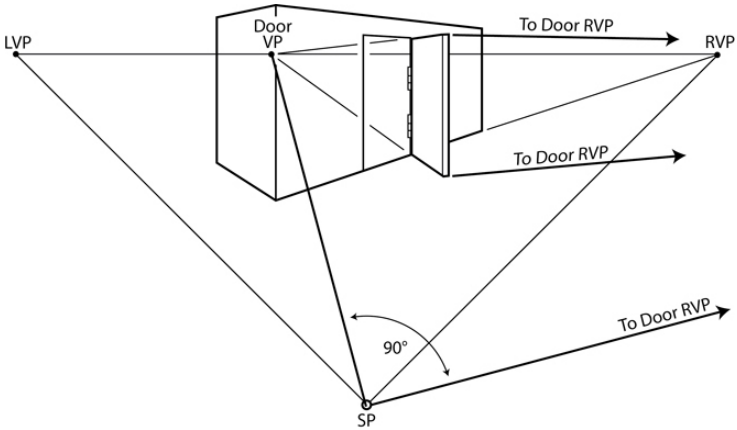


Figure 7.13 Completed door. To draw the thickness, project a 90° angle at the station point. **Return to text.**↵

chapter 7
Horizontal Angles

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76. There is a one-to-one relationship between true angles at the station point and perspective angles from vanishing points. The station point serves as the axis (center point) for angles. Around the station point are angles totaling 360° (Figure 7.1). It is worth reviewing Chapter 5, as this content builds on that foundation.

True angles at the station point mirror the perspective angles drawn from the vanishing points. An angle drawn from the station point, projected to the horizon line, creates a vanishing point that will draw that same angle in perspective. For example, to create a line 30° to the right of the center of vision, draw a true 30° angle at the station point. Project that angle to

the horizon line. The resulting vanishing point will draw 30° angles in perspective (Figure 7.2). Keep in mind there are 360° to consider. Here is another example: to create a line 130° to the right of the center of vision, draw that angle at the station point and project it to the horizon line. The resulting vanishing point draws that angle in perspective (Figure 7.3).

An Example of Horizontal Angles

Most objects have right angles. But there are instances where angles other than 90° are called for. For an example, try applying this understanding of angles to an illustration. A door makes an excellent demonstration, as doors can swing out and swing in. There are a full 360° of possibilities (Figure 7.4). Of course, these general concepts apply to any situation that involves angles other than 90°.

The Wall's Angle

Place the door on the right, opening out 60° from the wall. The first step is to determine the angle of the wall. The wall is in perspective, so to find the true angle of the wall, look to the station point. Angles at the station point are true angles. The line connecting the station point to the right vanishing point indicates the true angle of the right wall (Figure 7.5).

The Door's Angle

The station point is the axis point for true angles. The door's hinge is the axis point for perspective angles. Since the door's threshold projects forward, in front of the hinge, create that same angle at the station point (Figure 7.6)

This door opens outward 60°, so draw that angle at the station point (Figure 7.7). Project the 60° angle to the horizon line (Figure 7.8). This vanishing point draws angles that are 60° from lines drawn to the right vanishing point (Figure 7.9).

The Threshold's Length

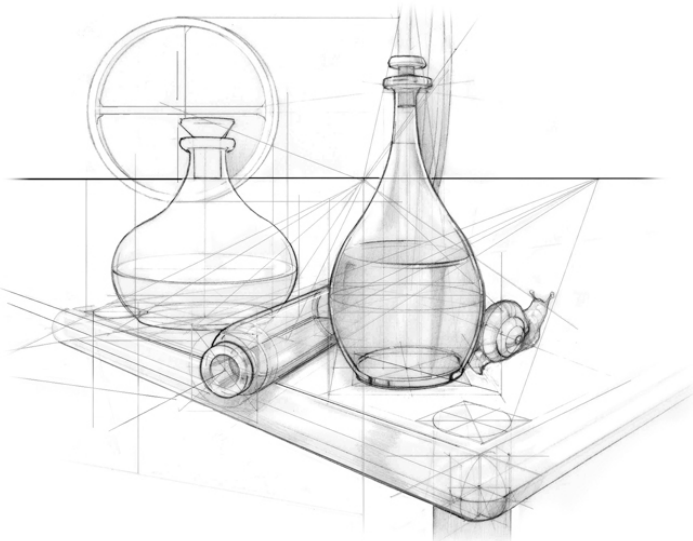
The door must close properly, so it must be the same length as the threshold. The next step is to measure the door. This is done with the right measuring point (Figure 7.10)

The Door's Length

After determining the length of the threshold, measure the door. Since every vanishing point has its own measuring point, a new measuring point for the door needs to be created (Figure 7.11). Measure the door using the door measuring point (Figure 7.12). Complete the door by connecting lines to vanishing points (Figure 7.13).

83. 84.

part five
Ellipses



85. 86.

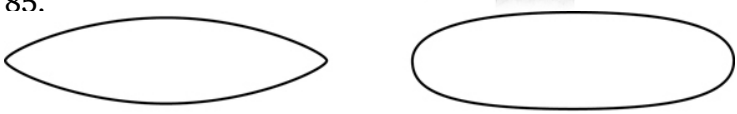


Figure 8.1 Two of the most common mistakes when drawing ellipses. **Return to text.**⏎

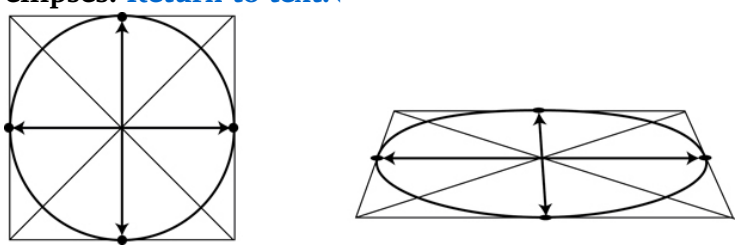


Figure 8.2 Drawing a four-point ellipse. **Return to text.**⏎

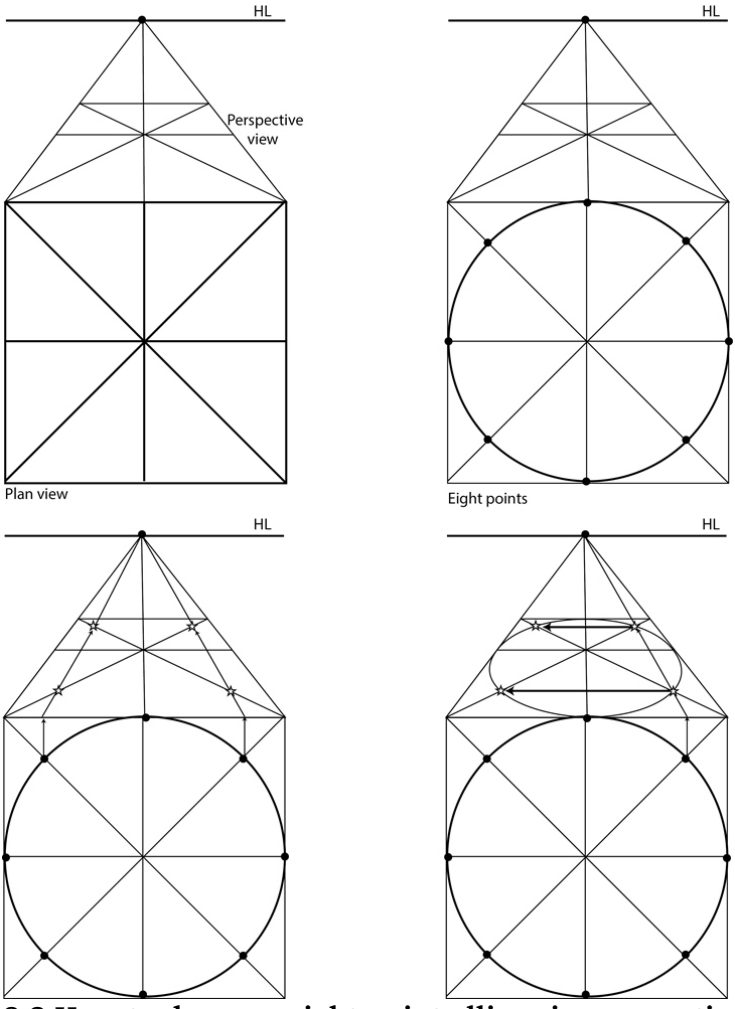


Figure 8.3 How to draw an eight-point ellipse in perspective.

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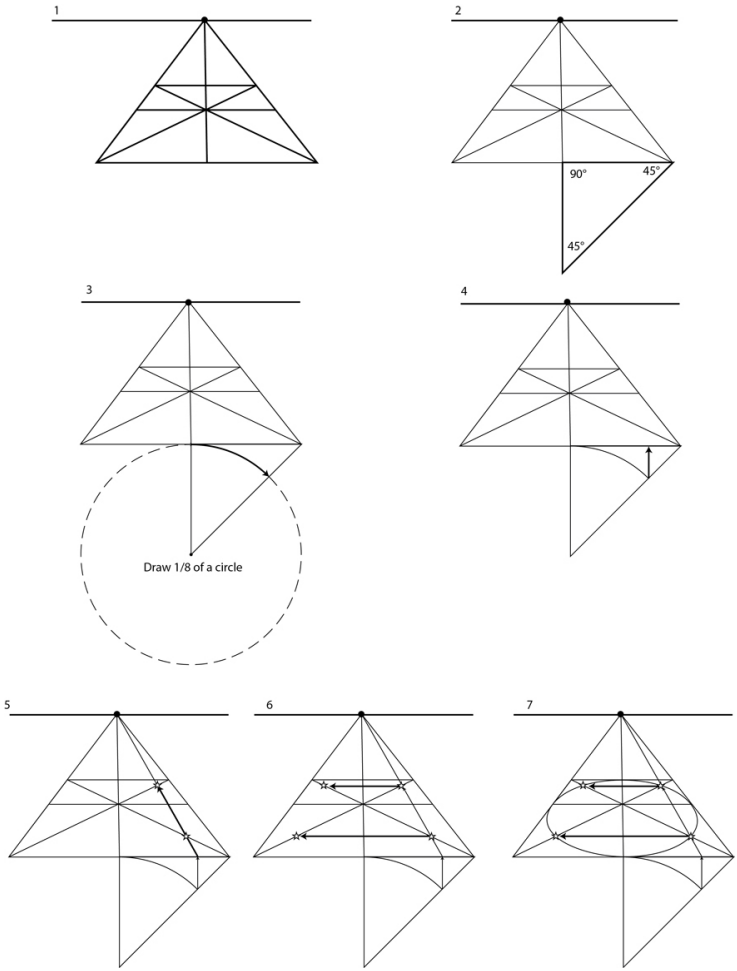


Figure 8.4 This is a shortcut to drawing an eight-point ellipse, saving time and space. **Return to text.**⏎ 88. 89.

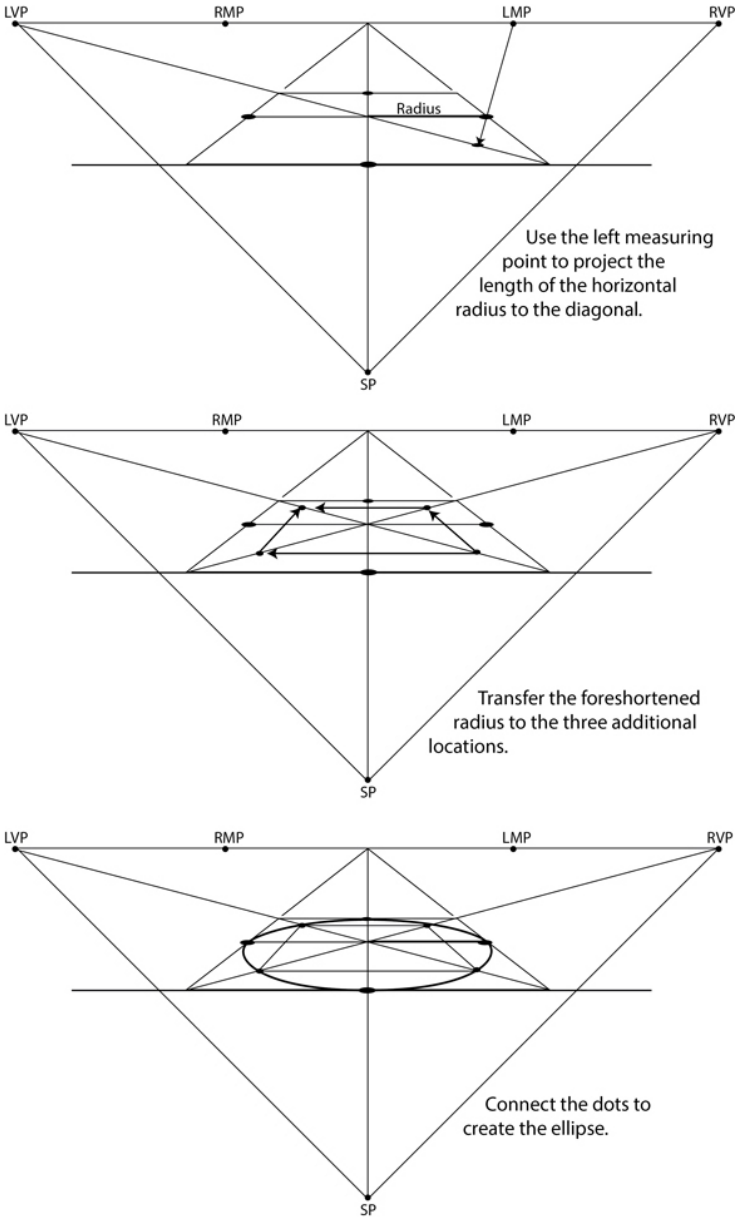
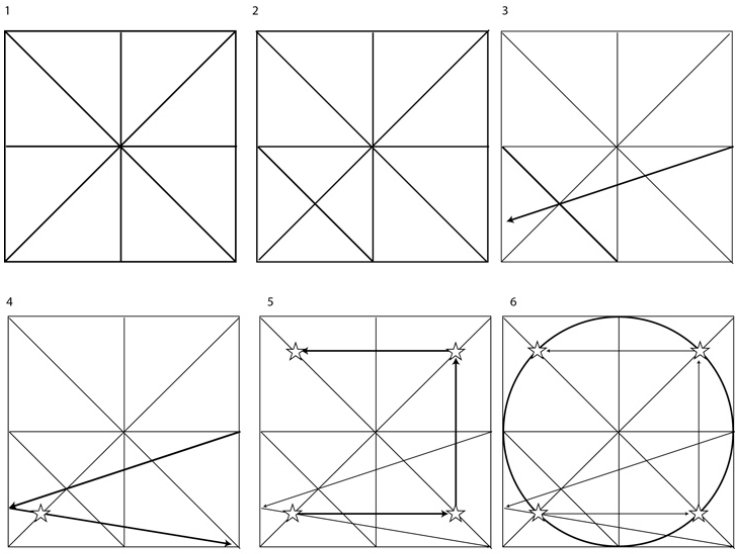


Figure 8.5 Using a measuring point to create an eight-point ellipse. **Return to text.** ⏎ 90.



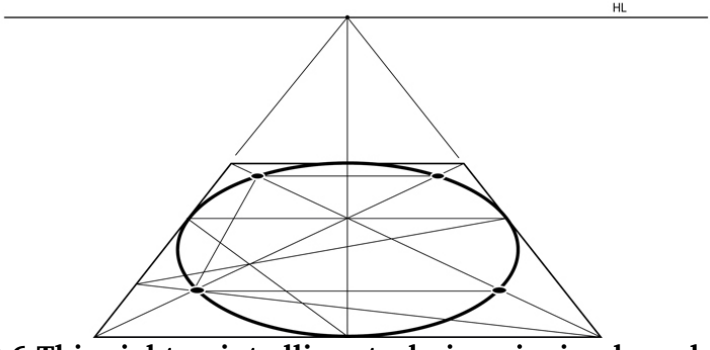
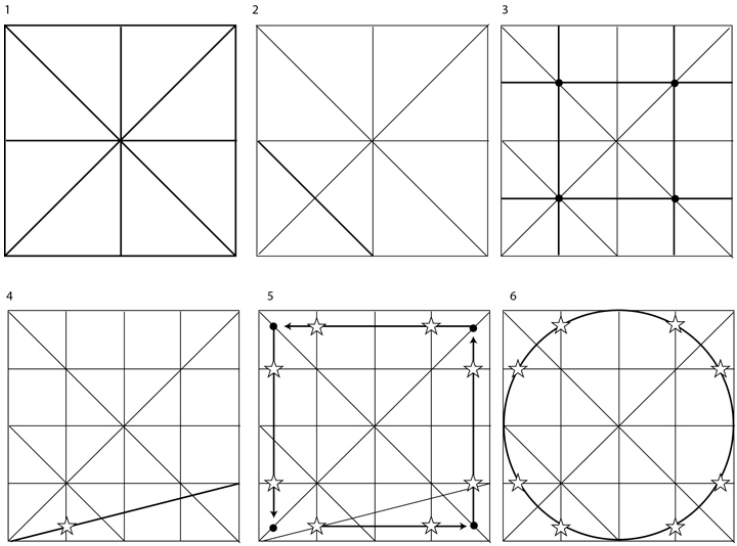


Figure 8.6 This eight-point ellipse technique is simple and compact. **Return to text.**⏎ 91.



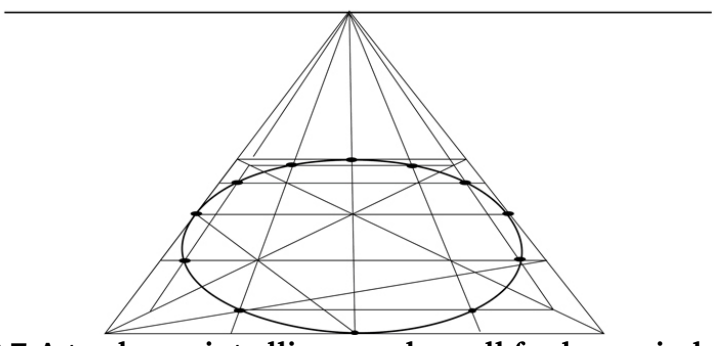


Figure 8.7 A twelve-point ellipse works well for large circles.
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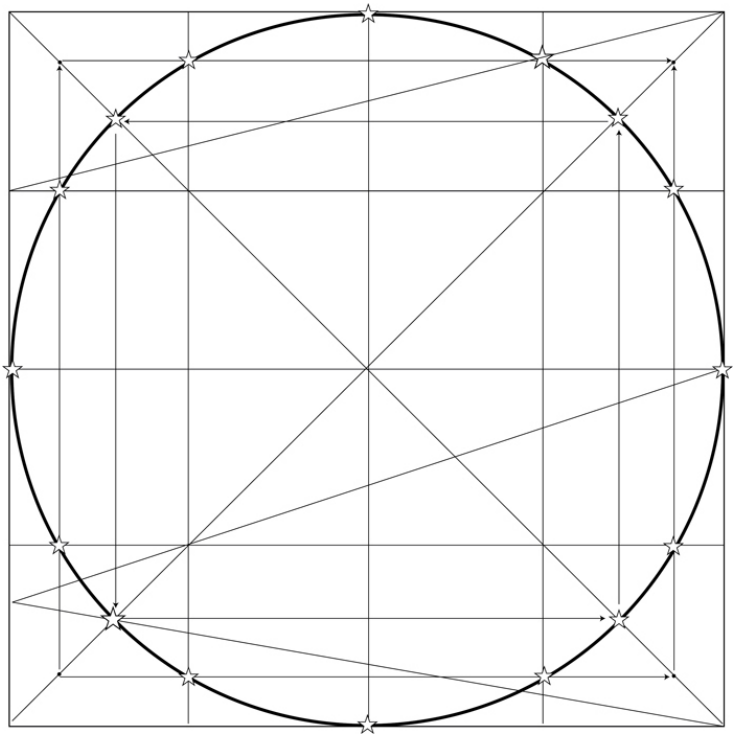


Figure 8.8 Sixteen points are used for very large ellipses. **Return to text.**

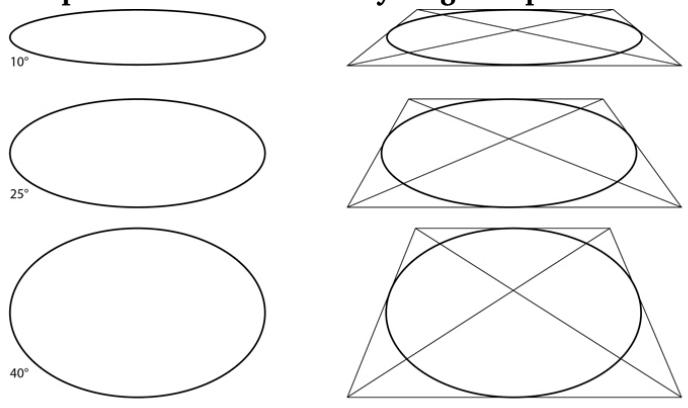
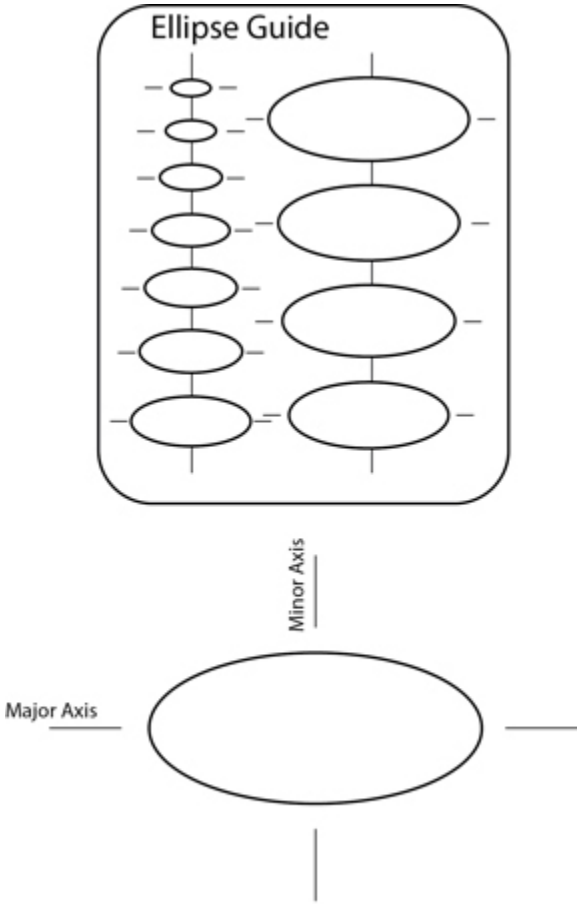


Figure 8.9 Using an ellipse guide requires drawing a square to determine which degree ellipse to use. **Return to text.**



93. Ellipse guide **Figure 8.10 The major and minor axis is printed on the ellipse guide (left). A three-dimensional view shows the minor axis oriented 90° from the ellipse's surface (right).** **Return to text.**⏎

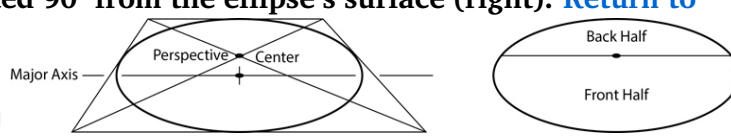


Figure 8.11 The perspective center of an ellipse is located behind the major axis. **Return to text.**⏎

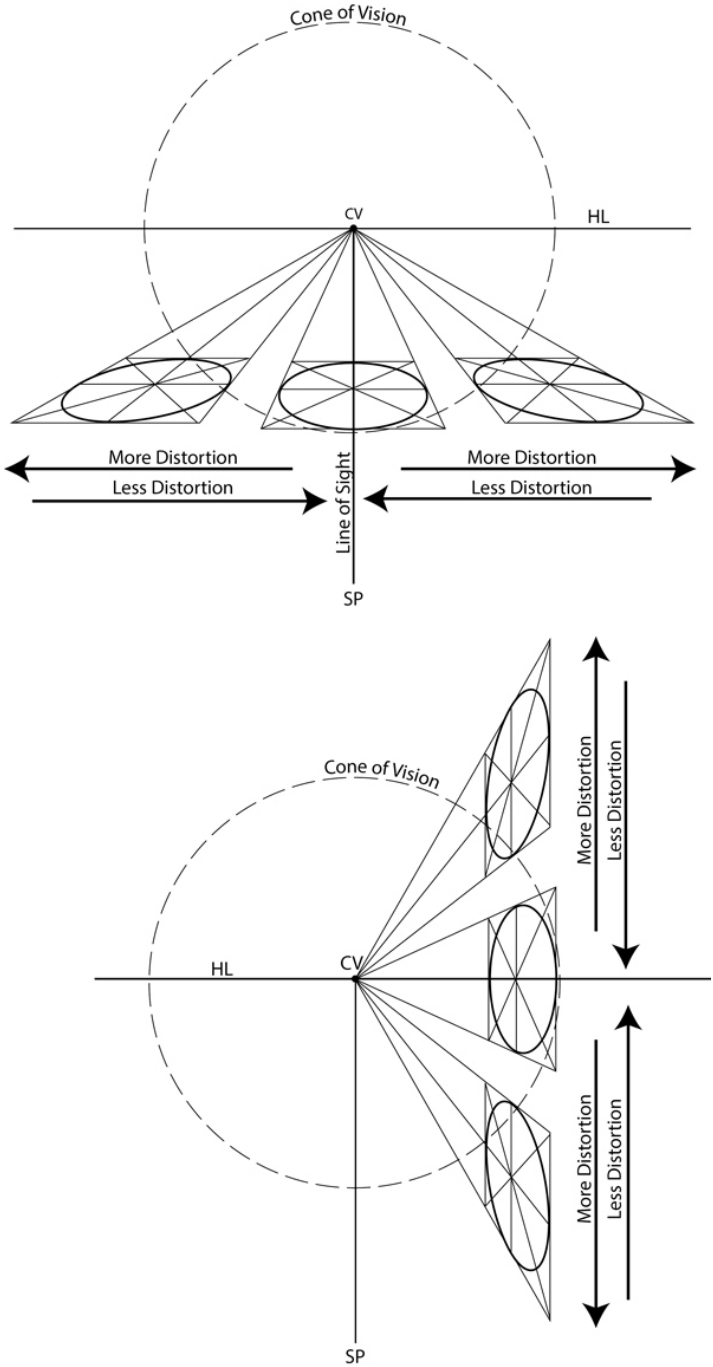


Figure 8.12 Horizontal ellipses become increasingly distorted as

they move away from the viewer's line of sight. Vertical ellipses become increasingly distorted as they move away from the horizon line. Return to text.

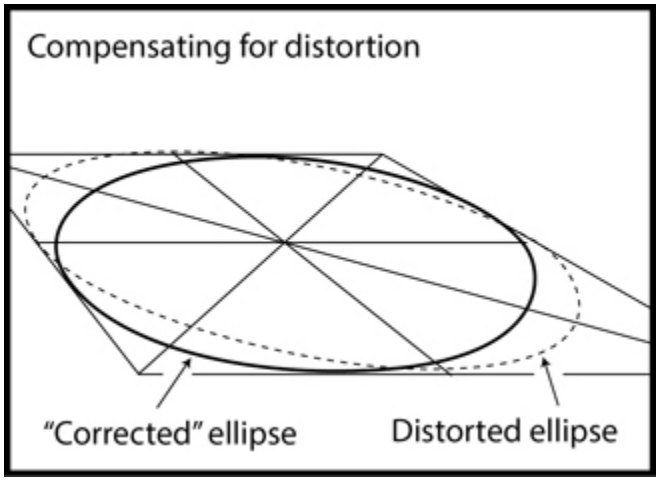


Figure 8.13 "Fixing" a distorted ellipse. Return to text.

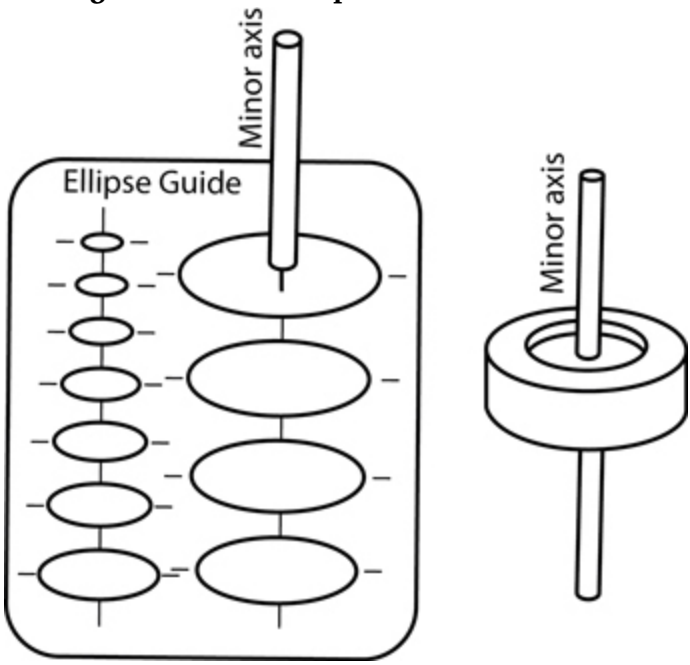


Figure 8.14 The minor axis goes through the ellipse at a 90° angle, like an axle of a tire. Return to text.

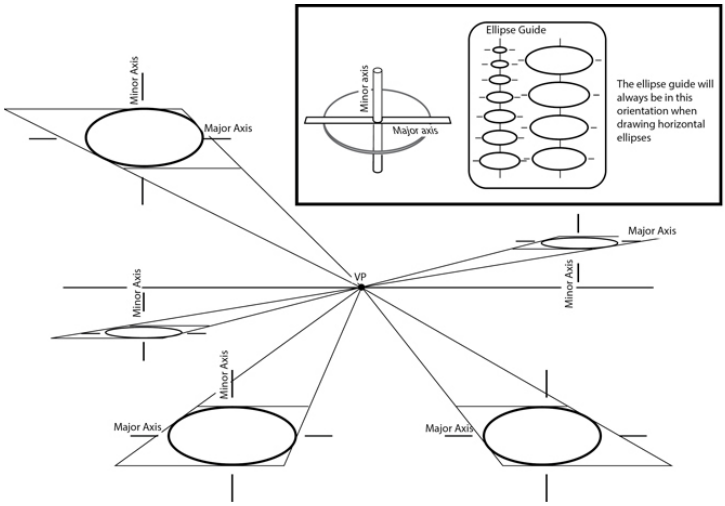


Figure 8.15 The minor axis is oriented vertically for all horizontal ellipses. **Return to text.**⏎

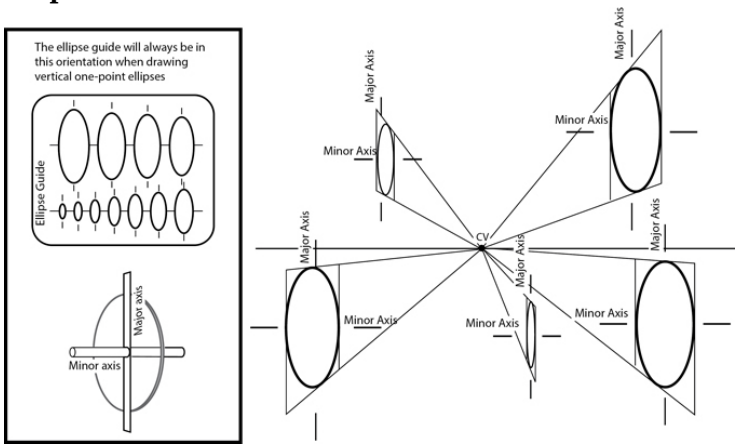


Figure 8.16 The minor axis is oriented horizontally for all one-point vertical ellipses. **Return to text.**⏎

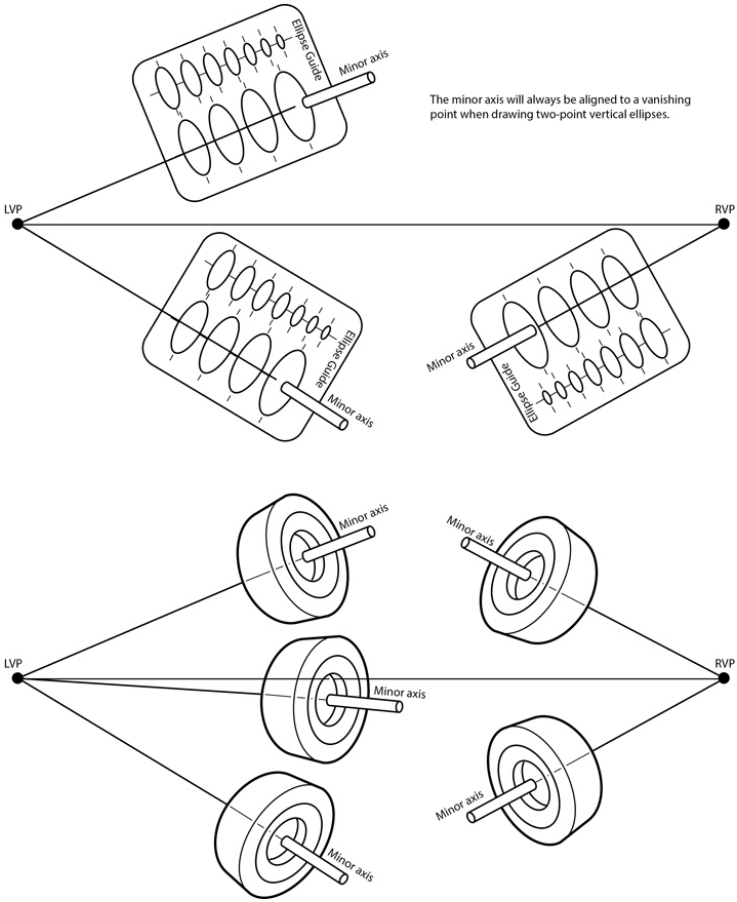


Figure 8.17 The minor axis is oriented to a vanishing point for all two-point vertical ellipses. Think of the ellipse as a tire and the minor axis as an axle. **Return to text.**⏎

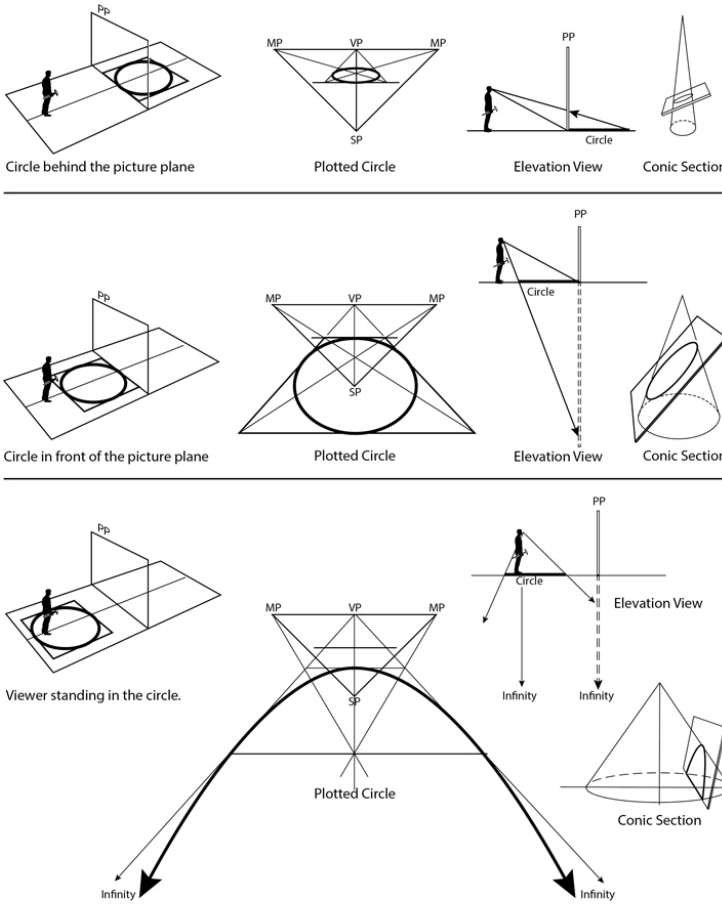


Figure 8.18 Most circles are plotted as an ellipse. If the viewer is inside a circle, the resulting shape will be a parabola or hyperbola. **Return to text.**⏎

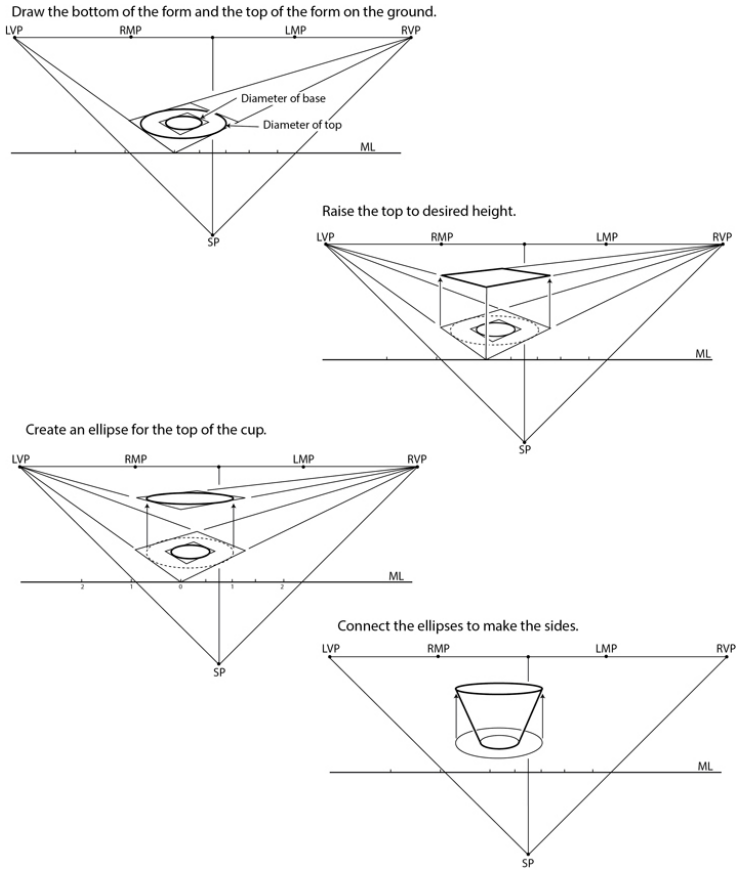
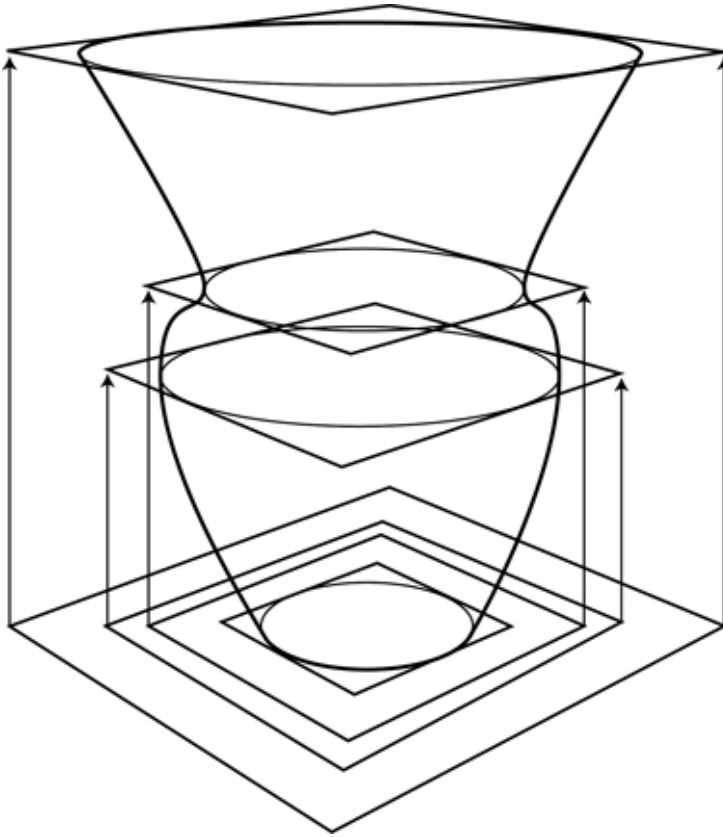


Figure 8.19 To draw tapered cylindrical forms, measure the diameter on the ground plane. Then project the ellipse to the desired height and connect the ellipses. **Return to**



text.⏎
Figure 8.20 Create squares on the ground plane, raise the squares to the desired height, draw ellipses, and then follow the contour to create a curved cylindrical shape.
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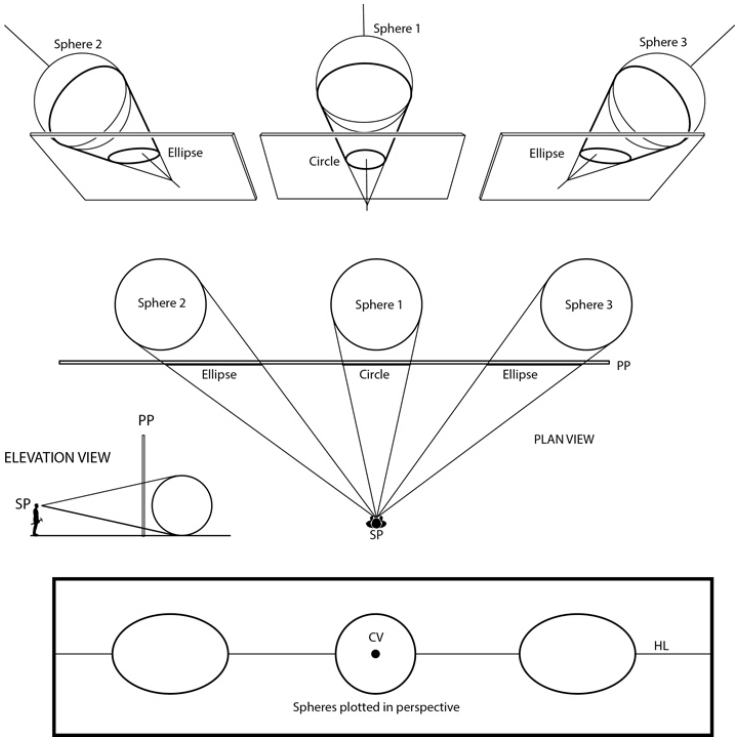


Figure 8.21 When an object is seen obliquely, distortion is inevitable. **Return to text.**⏎

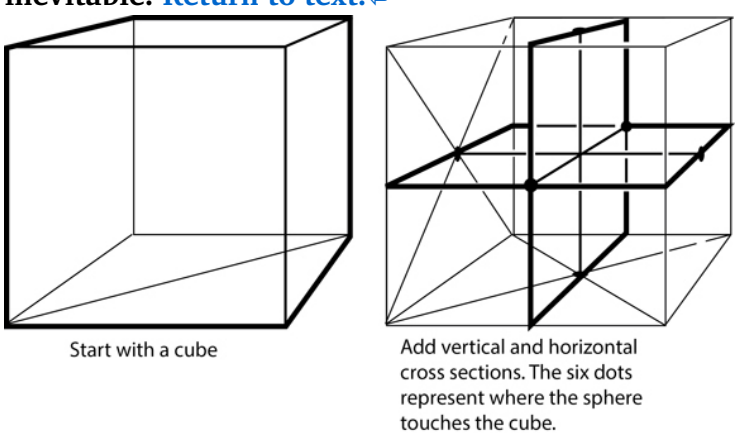


Figure 8.22Locating the six touch points of the sphere. **Return to text.**⏎ 102.

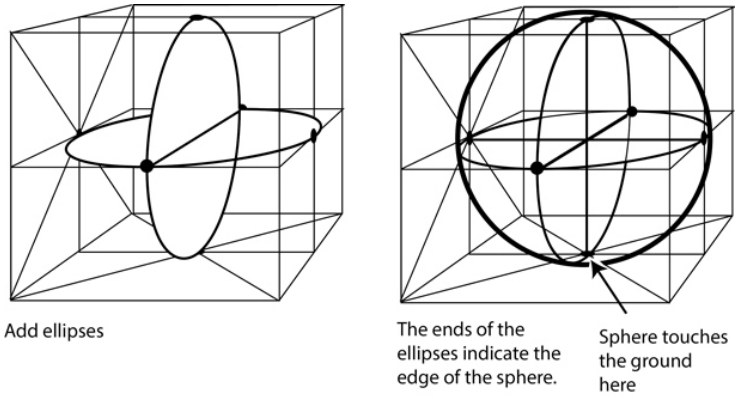


Figure 8.23 When drawing a perspective sphere, the horizontal and vertical cross-section determines the diameter of the circle. **Return to text.**⏎

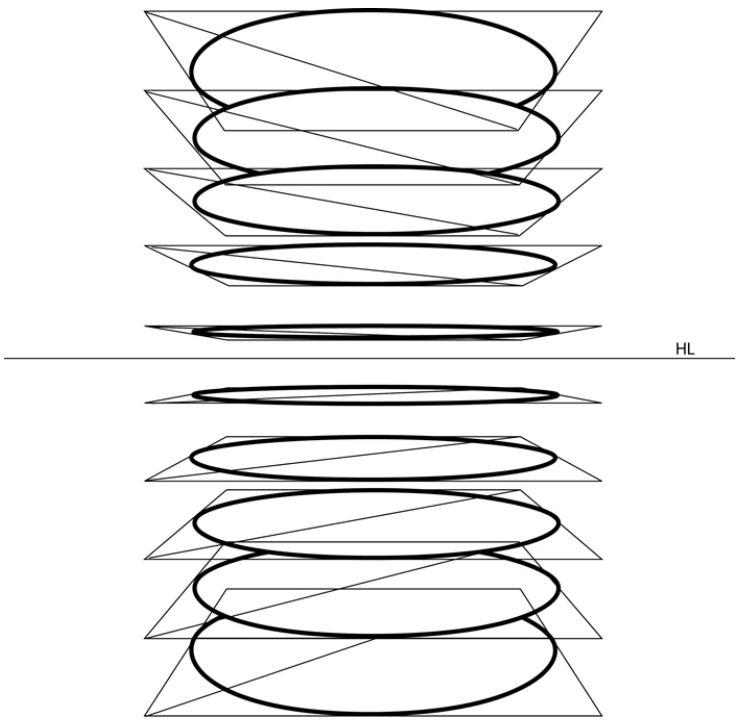


Figure 8.24 This stack of ellipses looks tight, but the resulting spiral will be surprisingly stretched. The ellipses need to be very close to achieve a tight spiral. **Return to text.**⏎

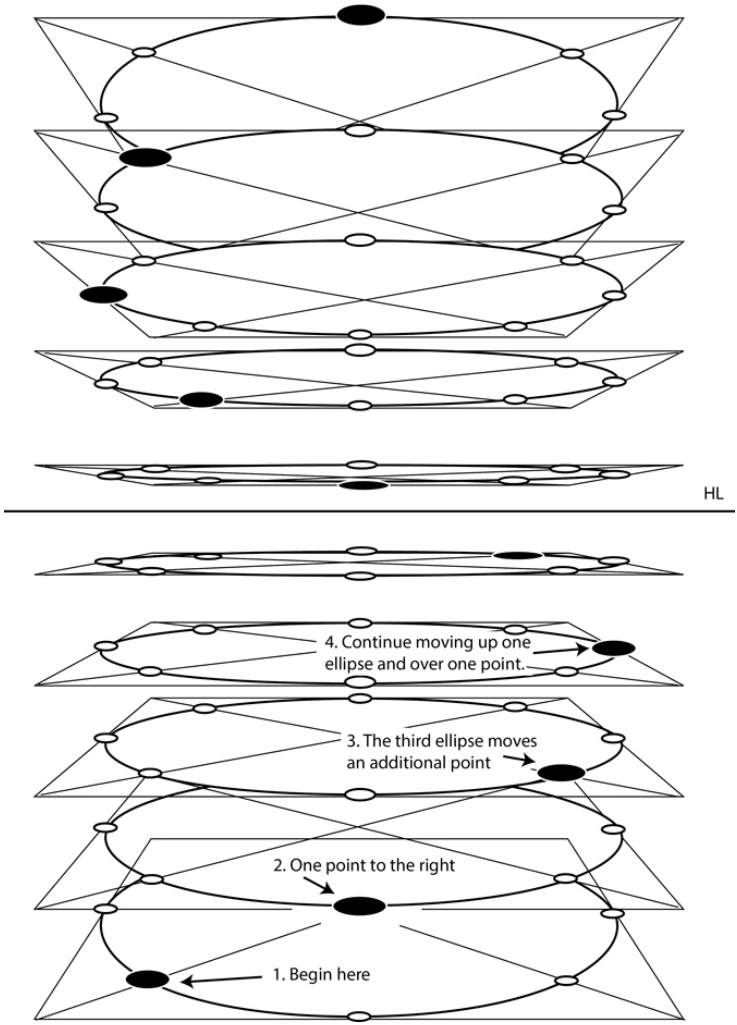


Figure 8.25 The solid dots represent points along the spiral. Each dot moves up one level and counterclockwise one-eighth of a turn. Using an eight-point ellipse, nine ellipses will make one complete coil. **Return to text.**⏎ 104.

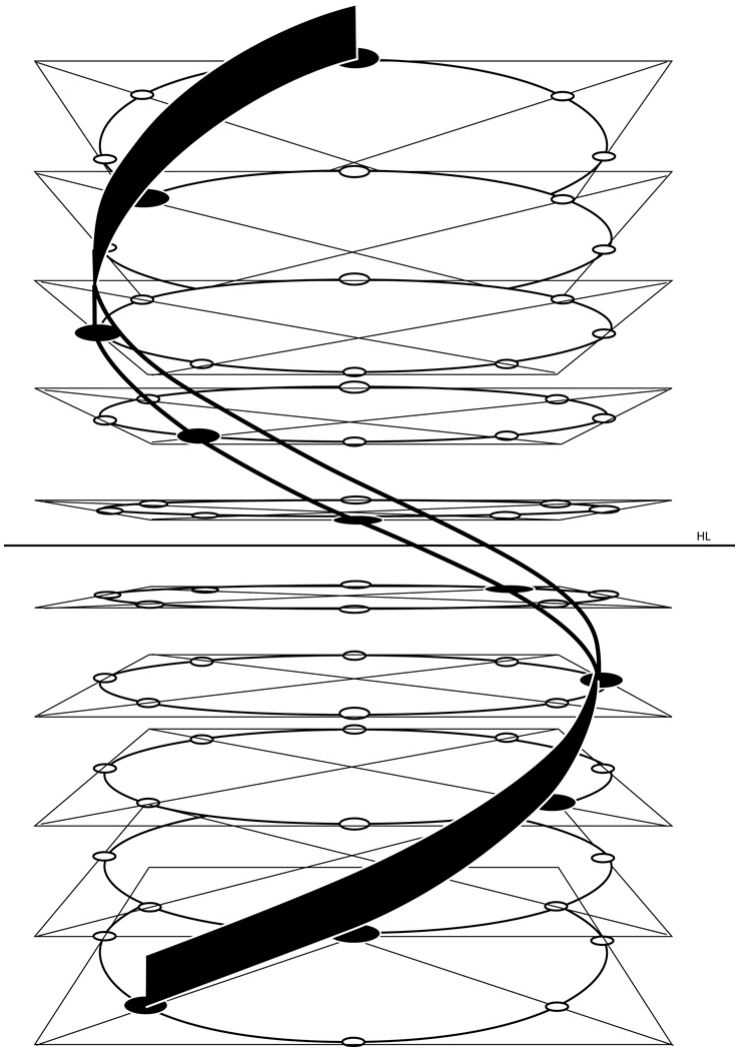


Figure 8.26 Connect the dots to create a spiral. Add an appropriate thickness to create a spring, barbershop pole, or any other form that wraps around a cylindrical object. **Return to text.**⏎ 105. 106.

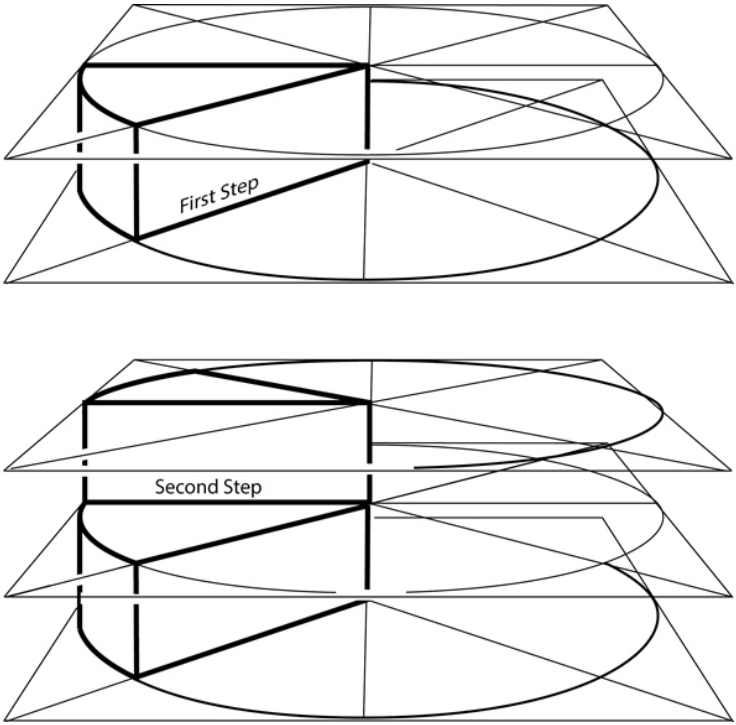
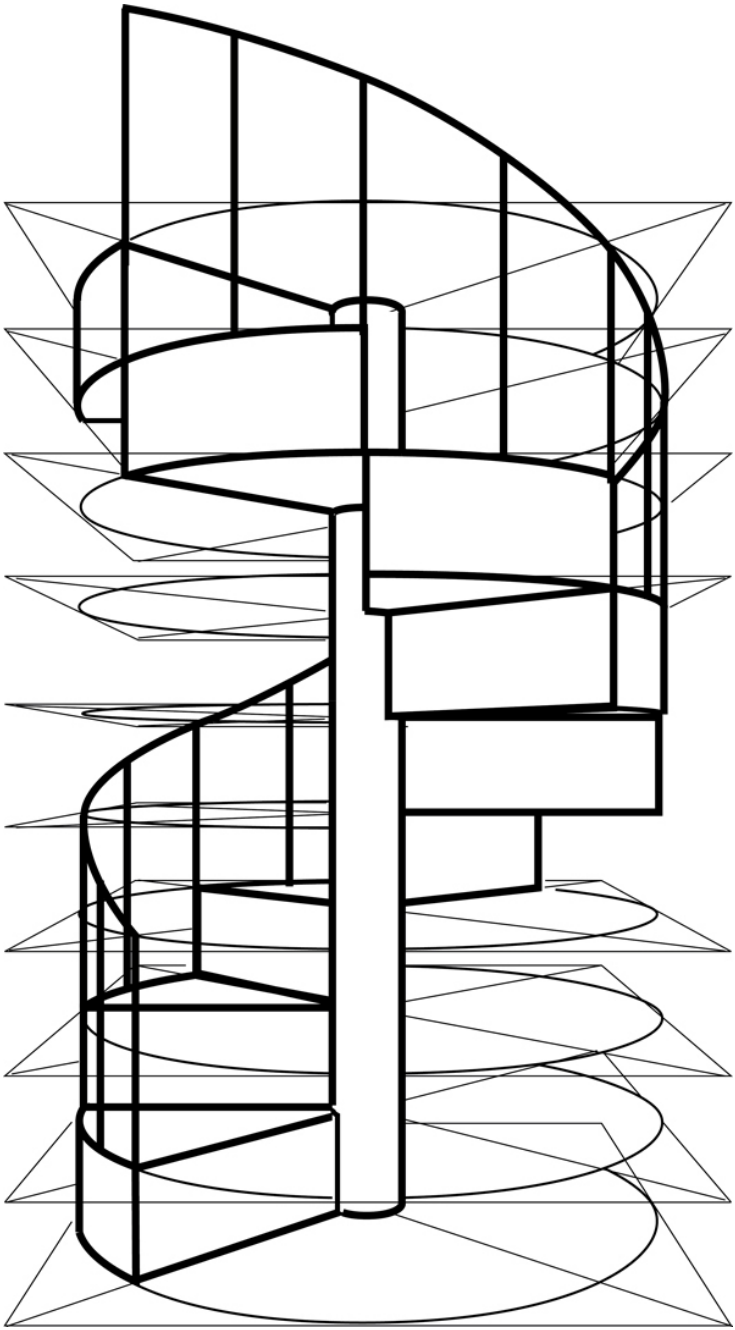


Figure 8.27 Build a spiral staircase one step at a time. Return to



text.⏎
Figure 8.28 Add a handrail to finish the staircase. Return to text.⏎ 107. 108.

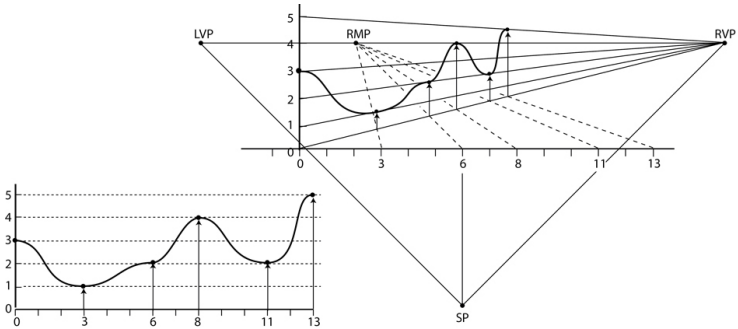


Figure 8.29 This curved line was first drawn in an elevation view (lower left). Key points along the curve were measured. Those points were then plotted in perspective. Connect the points to create a perspective curve (upper right). **Return to text.**⏎

chapter 8
Ellipses, Spheres, Spiral Forms, and Random Curves

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Ellipses

Ellipses are circles in perspective. When drawing freehand ellipses, the two common mistakes are pointy ellipses and flat ellipses (Figure 8.1). One way to avoid these mistakes is to plot points along the ellipse and connect the dots (a standard method for drawing any curved object). The more points plotted, the more accurate the curve. There are many ways to find these points. But they all accomplish the same task—they all draw circles in perspective. The techniques used to plot points are not especially complicated, but drawing smooth, beautiful freehand ellipses involves more than knowing how to

plot them. It involves a level of skill and finesse; it requires practice. The following pages illustrate some of the many methods, beginning with a four-point ellipse.

Four-Point Ellipse

Four points give a minimum amount of information to draw an accurate ellipse. But when used for small ellipses, it is usually adequate. Start by drawing a square. A circle touches a square at the center of each side—at four points. Locate these four points by finding the center of the square (draw an X through the corners), then project outward from the center point. Connect the four points with a smooth curve (Figure 8.2). Four points work well for small ellipses. For larger ellipses, it is desirable to have more points. The more points there are, the more accurate the ellipse.

Eight-Point Ellipse (First Method)

The eight-point ellipse is the most popular. Having eight points, each being 45° apart, gives an accurate guide to draw most ellipses. There are many ways to draw an eight-point ellipse. One of the oldest methods used to find these additional four points 87. begins by drawing a true circle. The four points are then transferred from the true circle to the perspective ellipse (Figure 8.3).

Shortcut

This method works well but can be time consuming, as there are quite a few unnecessary lines. Instead of drawing the entire true circle, draw 1/8th of a circle. Once one point is plotted, that point can be transferred to the other three locations (Figure 8.4).

Eight-Point Ellipse (Second Method)

This is the most streamlined—and arguably the simplest—method to plot an ellipse. Here's how it works. Four points of the ellipse touch the square. The other four points are located on the diagonal lines. The diagonal lines have a vanishing point; they are foreshortened. The horizontal line representing the radius of the ellipse is parallel to the picture plane, so it is not foreshortened. Use this horizontal line as a measuring line. Using the appropriate measuring point, transfer the length of the un-foreshortened radius to the diagonal line (Figure 8.5). This method works well for horizontal ellipses. It also works for vertical ellipses but is a bit more complicated. It involves using auxiliary vanishing points and auxiliary measuring points. This technique is best confined to horizontal ellipses.

Eight-Point Ellipse (Third Method)

This method is quick and relatively simple. It uses few lines to find the eight points, but this procedure is not 100% accurate. It is extremely close but not mathematically exact. It creates a radius along the diagonal, slightly longer than it should be (about 2% longer). This is a minor variation when trying to create accurate-*looking* hand-drawn ellipses. The extra 2% is an insignificant number, hardly noticeable (Figure 8.6).

Twelve-Point Ellipse

The more points that are plotted, the more accurate the ellipse. This method creates twelve points. As with the previous method, these points are not mathematically correct but are very close: close enough to make the deviation insignificant for hand-drawn ellipses. This method is best used for larger ellipses. Follow the steps to find the twelve points (Figure 8.7).

Sixteen-Point Ellipse

Combining the eight-point and the twelve-point method creates an ellipse with sixteen points. This is a lot of points to draw, but

when drawing a large ellipse, a greater number of points is more desirable (Figure 8.8).

Ellipse Guides

Ellipse guides may seem the obvious solution to drawing an ellipse. They are convenient, fast, and create perfectly smooth ellipses, but there are several important items to be aware of when using ellipse guides as well as computer generated ellipses. Ellipse guides come in sets that commonly range from 10° to 80° in 5° increments. Decide which degree to use by drawing a square in perspective. The proportions of the square will determine which guide to use (Figure 8.9). The ellipse guide may not fit the square perfectly. There is no 23° ellipse guide, so sizing up or down is the quickest option.

An ellipse guide has a minor axis (the center of the short side) and a major axis (the center of the long side). These axes are marked on the guides, usually by crosshairs. These crosshairs indicate the true center of the ellipse (Figure 8.10). They define the ellipse as symmetrical, vertically and horizontally. A perspective ellipse is not symmetrical; the front half of the circle is closer to the viewer than the back half. Therefore, in perspective, the shape of the front is different than the shape of the back. The major axis on the ellipse guide does not represent the perspective center of the ellipse. The perspective center of an ellipse is located behind the major axis (Figure 8.11).

Distortion

Distortion can happen with all objects. This is an unavoidable byproduct of perspective. Ellipses, however, seem especially sensitive to this problem. As ellipses stray to the left or right of the line of sight, they tend to look inclined, elongated, and asymmetrical (Figure 8.12). These distorted ellipses can be seen in many historical paintings. It is a frustrating predicament. The ellipses are plotted correctly but look askew if seen from a viewpoint different than what the image was plotted from. An

ellipse will only look correct if seen from the station point's location. Unfortunately, the person looking at a drawing will likely have their eyes at a location that is not aligned with the center of vision and not at the correct distance from the picture plane.

One way to make an ellipse appear correct from any viewpoint is to "cheat" the ellipse. The shape is modified so the ellipse appears visually correct. This, of course, makes them wrong in perspective but eliminating or reducing distortion 94. makes them more convincing than if plotted correctly. To put it more succinctly, the ellipse is drawn wrong to appear correct. When done freehand, this requires a bit of artistic surgery and eyeballing. Modify the shape so the left side of the ellipse appears symmetrical with the right side (Figure 8.13). If the left and right side of an ellipse are symmetrical, the ellipse will look flat.

The same "cheating" can also be done using an ellipse guide. This is accomplished by properly orienting the ellipse guide to the ground plane and horizon line. When desiring ellipses that *look* correct over ones that *are* correct, orienting the minor axis properly is crucial. The box that determines the degree of ellipse to be used and the plotted points within the box are not going to align with the ellipse guide. It may be helpful to understand the minor axis three-dimensionally. The minor axis goes *through* the circle. It is like an axle on a tire: it intersects the center of the ellipse at a right angle (Figure 8.14).

Ellipse Orientation

When correcting for distortion, the correct orientation of an ellipse guide is determined by the direction of the minor axis. Horizontal ellipses are oriented differently than vertical ellipses, and one-point vertical ellipses are oriented differently than two-point vertical ellipses.

Horizontal Ellipses

To remove distortion and make all horizontal ellipses look flat, orient the minor axis vertically. It does not matter where the ellipse is placed or if the ellipse is drawn in one- or two-point perspective. If the ellipse is parallel to the ground plane, then the minor axis is oriented vertically: parallel to the picture plane and perpendicular to the ground plane (Figure 8.15).

One-Point Vertical Ellipses

To remove distortion on all one-point vertical ellipses, orient the minor axis horizontally, parallel to the ground plane and the picture plane (Figure 8.16).

Two-Point Vertical Ellipses

To eliminate the effect of distortion on vertical two-point ellipses, align the minor axis to a vanishing point. But there are two vanishing points—which one does the minor 95. 96. 97. axis connect to? It is helpful to think of the minor axis as an axle on a tire. The minor axis—like an axle—goes *through* the ellipse. The minor axis is 90° from the surface of the ellipse (Figure 8.17).

The Ellipse, the Parabola, and the Hyperbola

Circles projected to the picture plane create a conical section resulting in an ellipse (Figure 8.18, top). Large circles, or circles outside of the cone of vision, create distorted ellipses (Figure 8.18, center). If the viewer is standing inside the circle (e.g., someone 98. in a stadium or sports arena) the only part of the circle that can be plotted is in front of the viewer. Objects behind the viewer cannot be projected on a flat picture plane. The resulting shape is not an ellipse but a parabola or hyperbola, an open-ended curve that continues to infinity (Figure 8.18, bottom).

Tapered Forms: Cups, Bottles, and the Like

To draw cylindrical forms with various diameters, first draw squares of the appropriate size on the ground plane. Raise each square to the desired height. Then draw an ellipse in each square. For example, a simple tapered cup will have a smaller-diameter 99. ellipse on the ground and a larger-diameter ellipse above. Draw both on the ground (Figure 8.19, top). Then project the top of the cup to the desired height. Connect the two ellipses to create the cup (Figure 8.19, bottom).

For complex forms of varying diameters, make more ellipses. The ellipses serve as key cross-sections and guide the contour of the form—the more ellipses, the more accurate the shape (Figure 8.20).

Spheres

Drawing a sphere in perspective is more complicated than one might think. A compass can be used to draw a circle and considered finished. But if a specific size or placement 100. for the sphere is desired, then a cube must be drawn first. The sphere fits into the cube, touching the center of all six sides. The cube defines where the sphere touches the ground. The cube also defines the diameter of the sphere.

Distortion

Before discussing how to fit the sphere into the cube, some issues concerning the shape of the sphere will be explored. After reading the section on ellipses and distortion, it may not be surprising that spheres drawn in perspective are not necessarily round. Just like drawing a circle in perspective, a sphere becomes more distorted as it moves farther away from the center of vision.

A look at conic sections can further explain this phenomenon. A conic section is the intersection of a plane and a cone. The silhouette of a sphere is circular. When that round shape is projected to the eye, a conical visual pyramid is created. A cone intersecting a flat plane at an oblique angle creates an ellipse

(Figure 8.21). Thus, a sphere plotted in perspective is not round unless its center is aligned with the focal point. A sphere plotted in perspective is an ellipse.

Any circular object not aligned with the center of vision is drawn elliptical by the rules of perspective. This elliptical shape will appear correct (circular) if seen from the position it was plotted. If the person looking at the drawing places their eye at the location of the station point, the ellipse will appear circular. But if a viewer looks at the drawing from a place other than where the image was plotted, the perspective sphere will appear elliptical. Ideally, spheres should look circular, not elliptical. When drawing spheres, as with ellipses, it is usually better for them look correct than to be correct. The bottom line: use a compass to make spheres.

First Draw a Cube

When using a compass to create a sphere, the sphere still needs to be a specific size and in a specific location. First draw a cube and bisect it vertically and horizontally, creating six touch points (Figure 8.22).

Draw an ellipse in the cross-sections (Figure 8.23, left). The edges of the two ellipses indicate the diameter of the sphere (Figure 8.23, right). These points are in perspective and will not align perfectly with a true circle. So this is where some “cheating” is applied.

Spiral Forms

Draw all sinuous lines by plotting points along the curve. A spiral is a stretched circle. It moves around as it moves up. Spiral forms are based on a series of stacked ellipses. A point is plotted along each ellipse. Closer ellipses create a tighter spiral. First, draw an ellipse representing the diameter of the spiral. Then decide on the spacing of each ellipse (Figure 8.24).

Each point on an eight-point ellipse represents one-eighth of a coil. A coil is one complete turn of a spiral. It takes nine points (nine ellipses) to create a complete coil.

Start at the bottom ellipse and pick a point to begin the spiral. Then, on the ellipse above, move one point (one-eighth of a turn) counter-clockwise (or clockwise 103. depending on the rotation of the spiral). Repeat this process, moving up one ellipse, and over one one-eighth a turn. As the point moves up, it also moves around the circle (Figure 8.25). Connect the dots, resulting in a spiral (Figure 8.26). The method is not difficult; it is just time consuming. It is also dense with lines. All spiral forms (springs, barbershop poles, candy canes, spiral staircases, etc.) are done using this basic technique.

Spiral Staircase

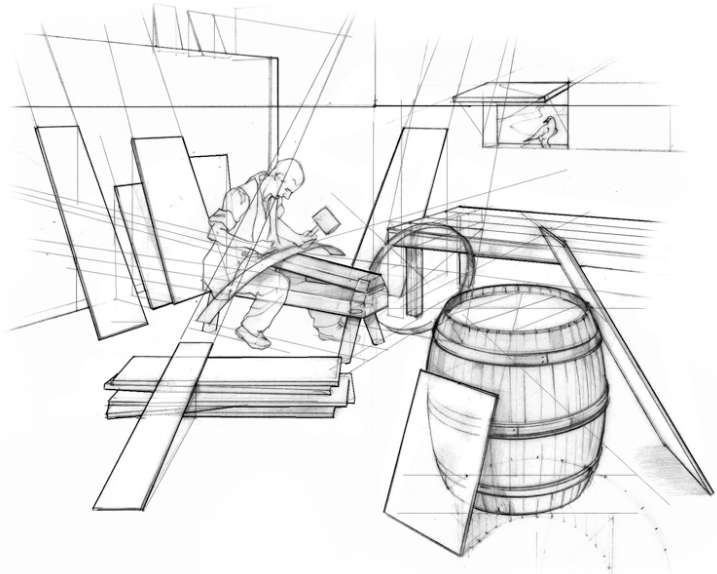
A spiral staircase is a series of triangles moving up and around a circle. It follows the same principles as any spiral form. First, decide on the size of the steps. Divide the ellipse like a slice of pie. Each slice represents one step. Draw one step. Then draw another, one level above the first. The third step is one level above the second, and so on. Each step moves to the left and up one level (spiral staircases always go up clockwise). The spiral staircase will turn and rise as each step is built (Figure 8.27). Continue adding steps. Draw handrails by following the same guidelines (Figure 8.28).

Random Curves

The solution to drawing sinuous or undulating lines where one shape flows seamlessly into another is not complicated. It is more tedious than elegant. Drawing curved lines involves plotting points along the curve and then connecting the dots. The more points that are plotted, the more accurate the curve. First, draw the serpentine shape in a plan or elevation view, a view without perspective. Measure key points along the curve. Then transfer those dimensions to a perspective view (Figure 8.29).

109. 110.

part six
Inclines



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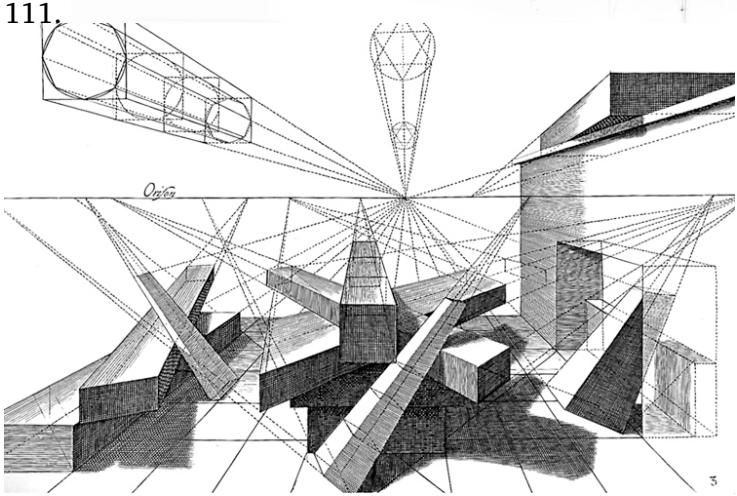
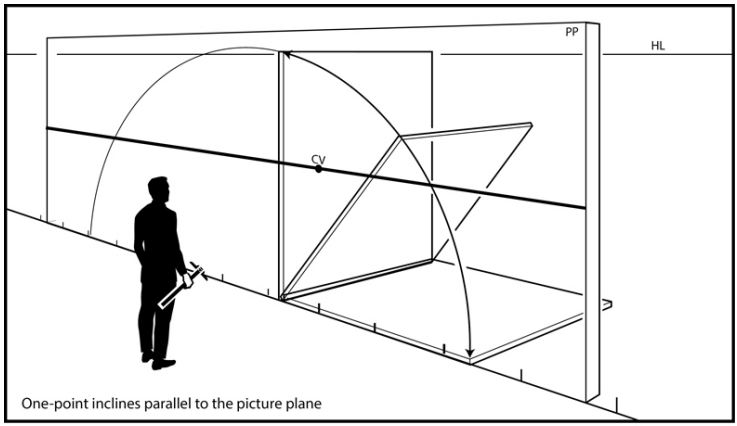
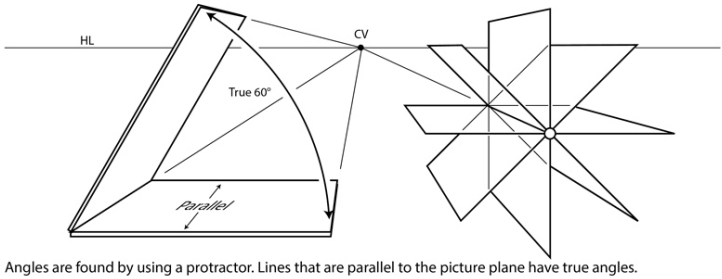
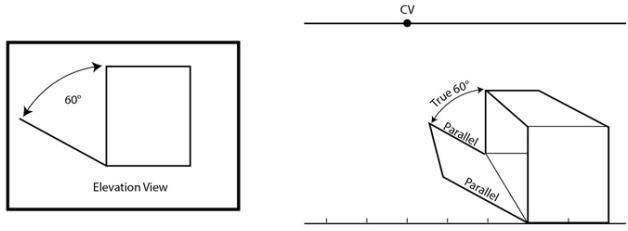


Figure 9.1 Jan Vredeman de Vries, *Perspective*, 1604. Notice the vanishing points for the inclines are erroneously placed on the horizon line. **Return to text.**⏎





Angles are found by using a protractor. Lines that are parallel to the picture plane have true angles.



This incline is not foreshortened. The angle is a true 60°.

Figure 9.2 Angles parallel to the picture plane have no vanishing points and are drawn as true angles. **Return to text.**⏎

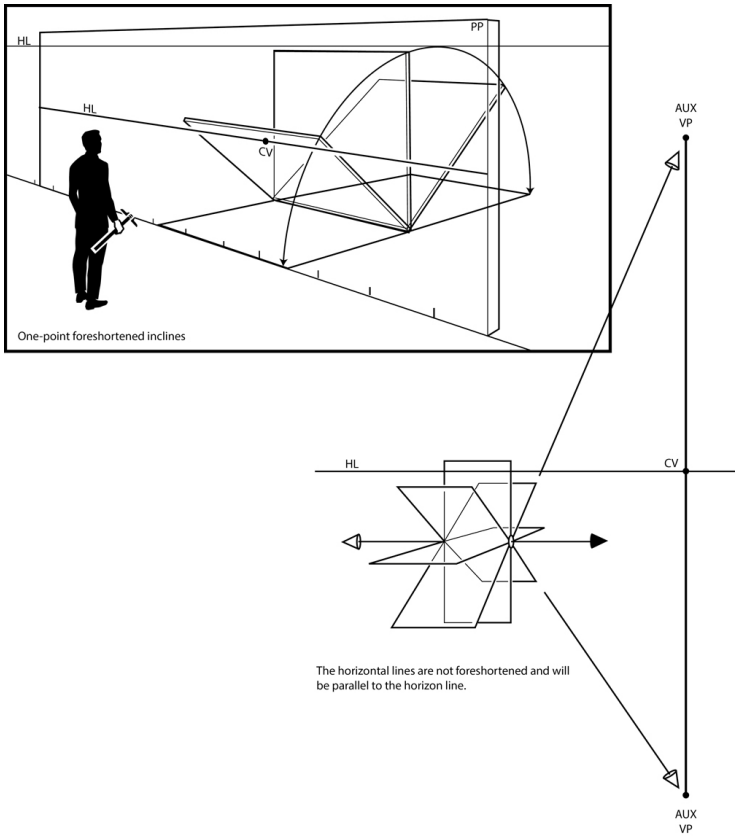


Figure 9.3Inclines not parallel to the picture plane are foreshortened and have vanishing points above or below the center of vision. **Return to text.**⏎ 115.

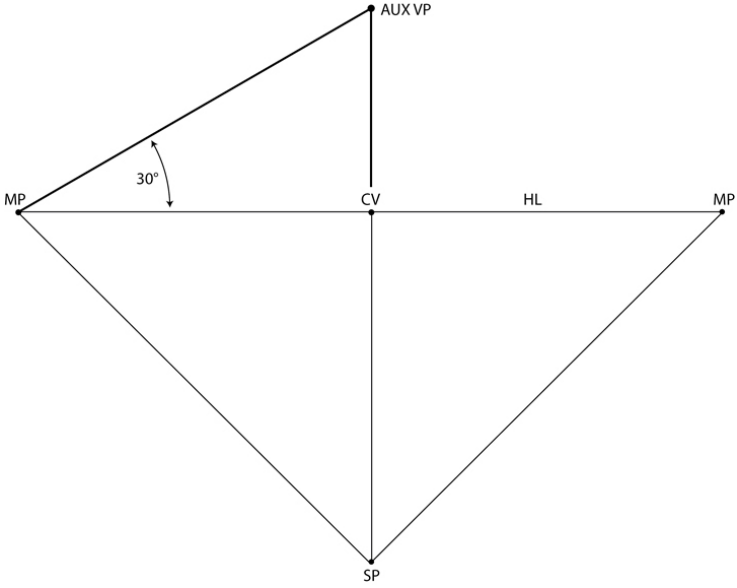


Figure 9.4 The measuring point is the true angle for inclines. Use the measuring point to establish the location of auxiliary vanishing points. **Return to text.**⏎ 116.

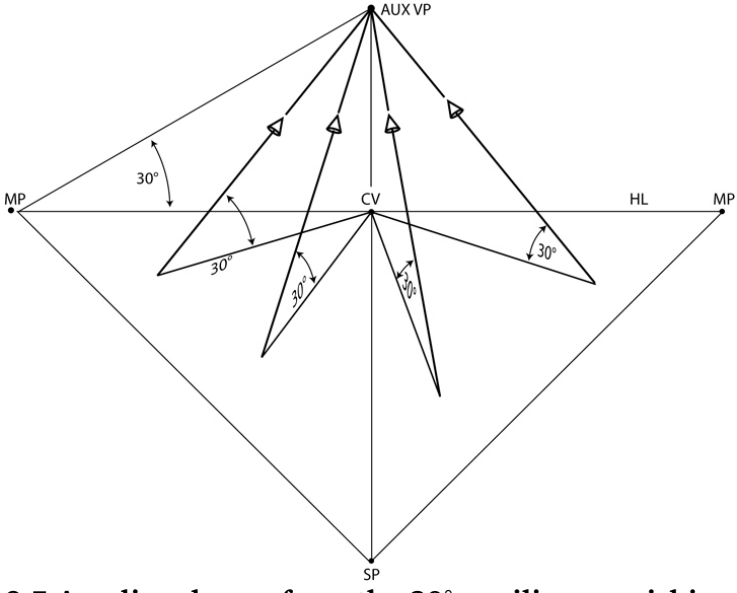
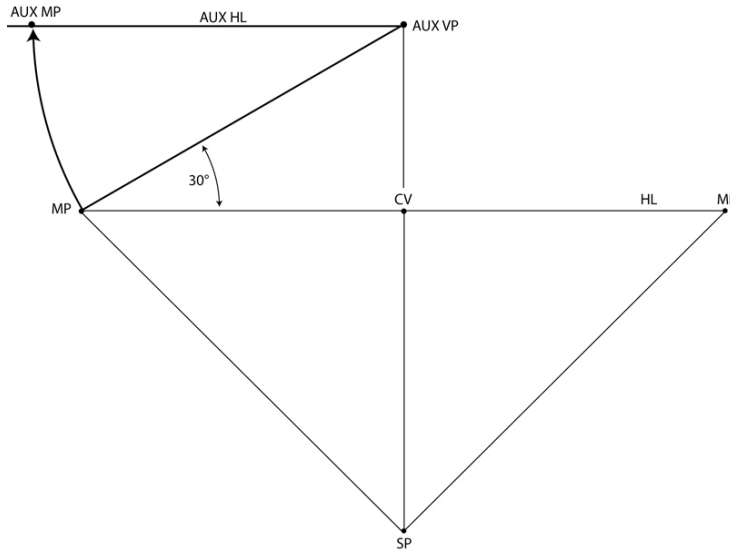


Figure 9.5 Any line drawn from the 30˚ auxiliary vanishing point creates an incline 30˚ from the ground plane. **Return to**



text.⏎
Figure 9.6The distance from the auxiliary vanishing point to the measuring point is the same as the distance from the auxiliary measuring point to the auxiliary vanishing point.
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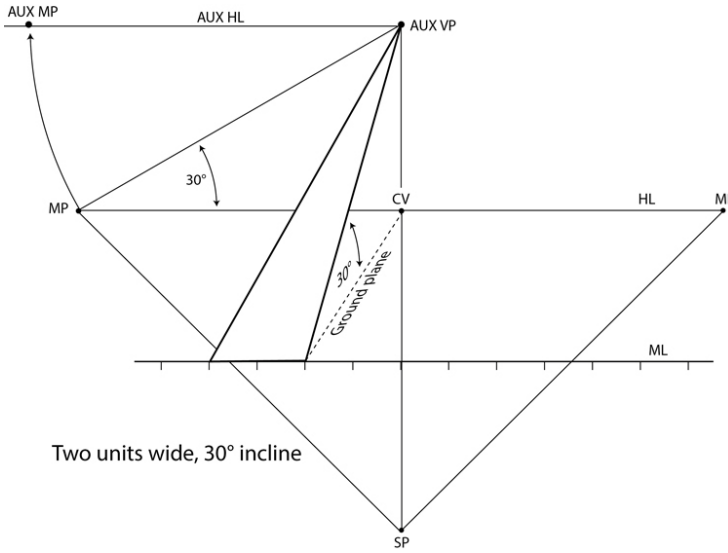


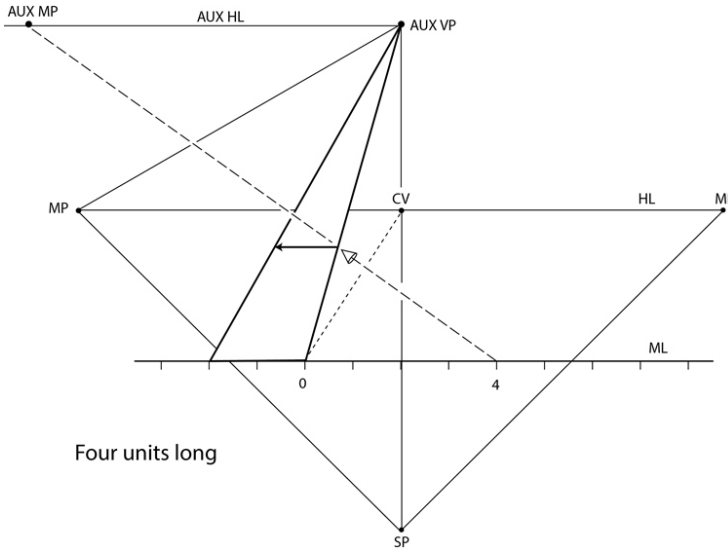


Figure 9.7 Measuring one-point inclines. Creating a 30° incline (above), and measuring a 4 unit length (below). **Return to text.**⏎ 118. 119.

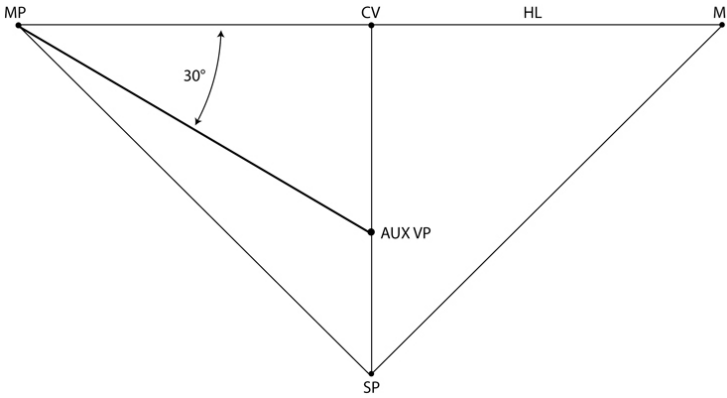


Figure 9.8 Use the measuring point to find the auxiliary vanishing point. **Return to text.**⏎

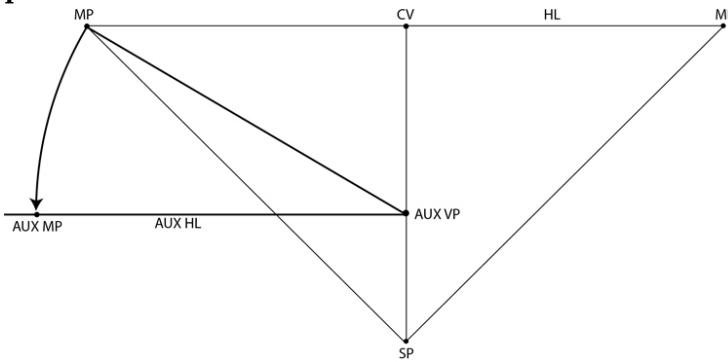


Figure 9.9 Create an auxiliary horizon line, then measure the distance from the auxiliary vanishing point to the measuring point and transfer that distance to the auxiliary horizon line. **Return to text.**⏎

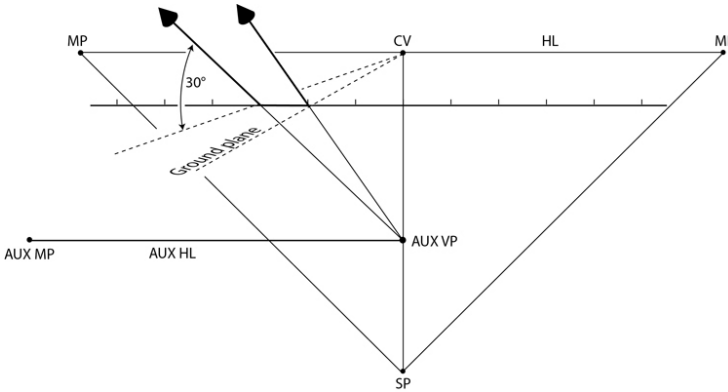


Figure 9.10 This auxiliary vanishing point draws inclines at a 30°

angle to the ground plane. **Return to text.**⏎ 120.

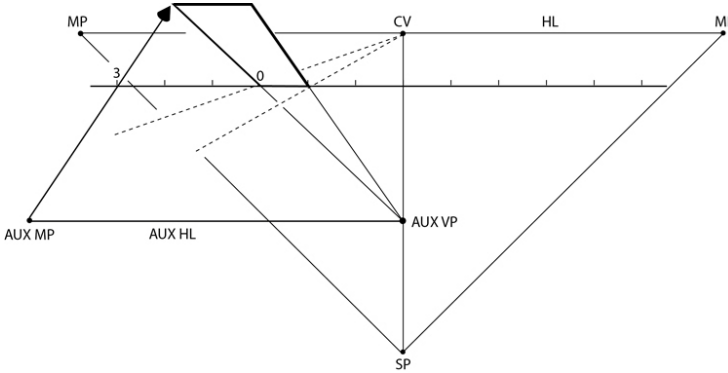
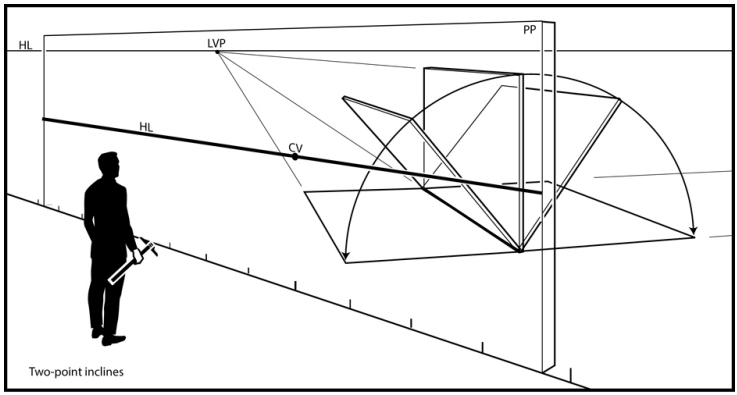
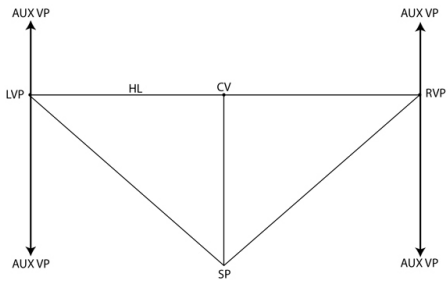


Figure 9.11 Use the auxiliary measuring point to measure the incline. Horizontal lines are parallel with the horizon line. **Return to text.**⏎ 121.





The auxiliary vanishing points will be aligned with right or left vanishing point.

The location of the auxiliary vanishing points will depend on the angle of the incline.

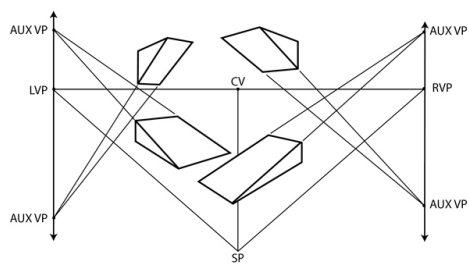


Figure 9.12 Two-point perspective auxiliary vanishing points are aligned with the left or right vanishing point. **Return to text.**⏎ 122.

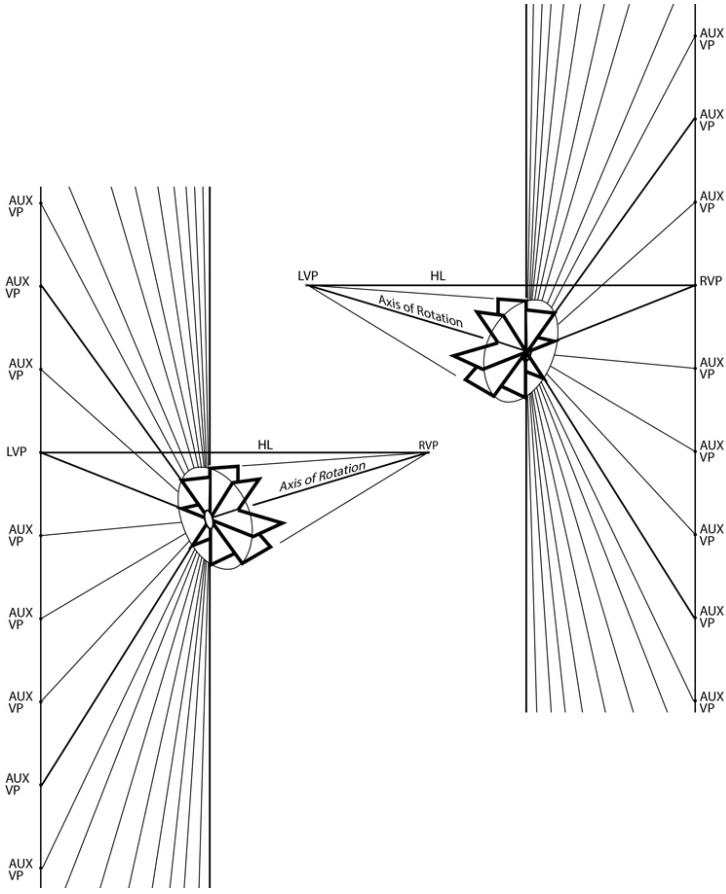


Figure 9.13 Auxiliary vanishing points are always opposite to the axis of rotation. **Return to text.**⏎ 123.

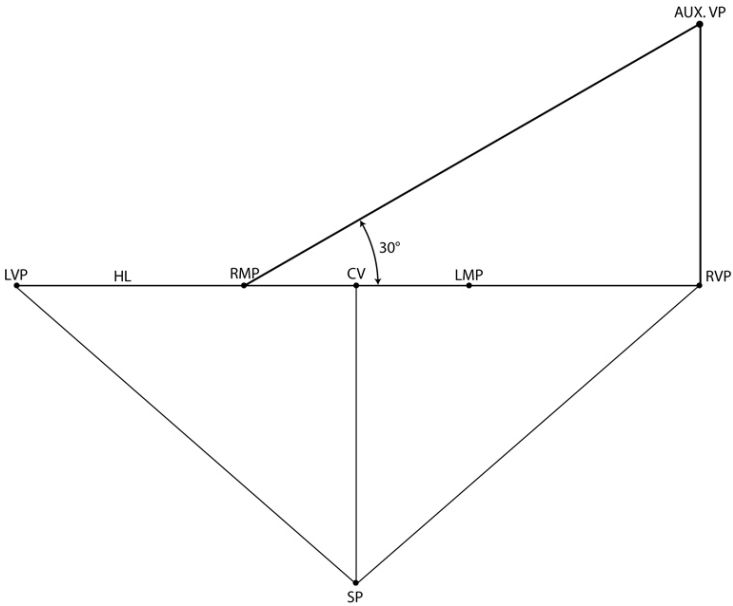


Figure 9.14 Use the measuring point to find the location of the auxiliary vanishing point. **Return to text.**⏎ 124.

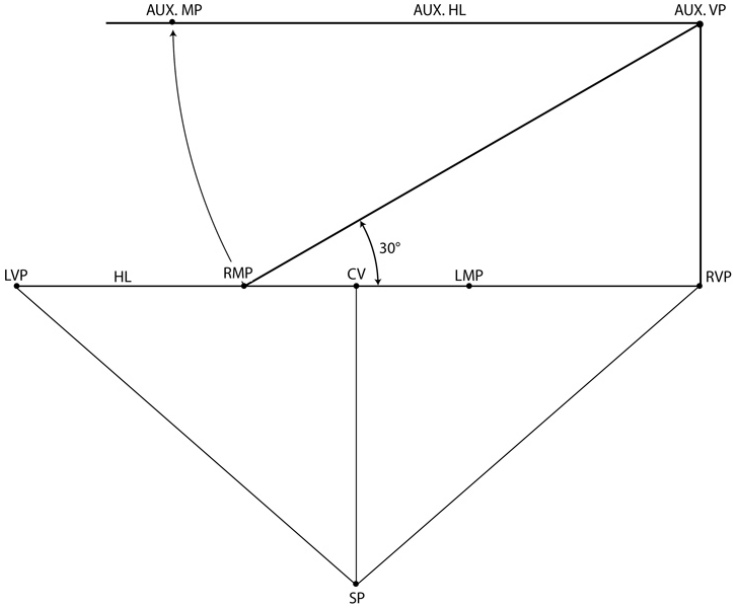


Figure 9.15 Use a compass or ruler to establish the auxiliary measuring point. **Return to text.**⏎ 125.

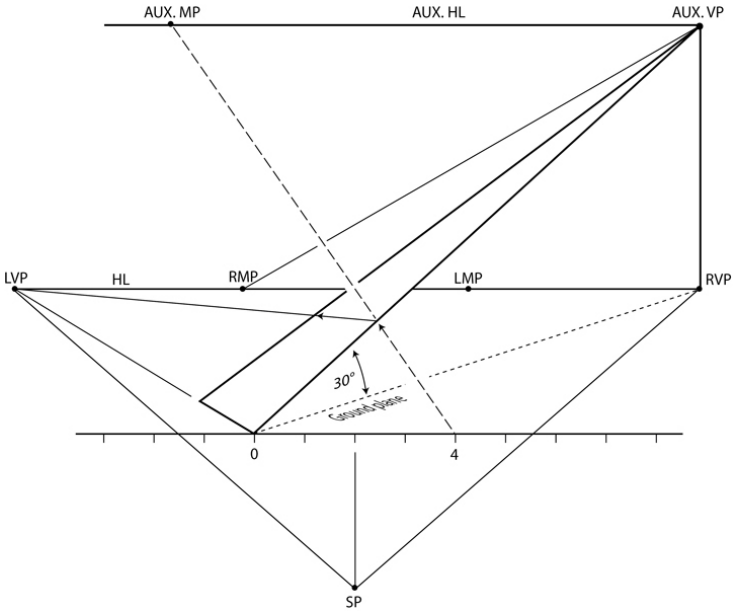


Figure 9.16 To measure an incline, the measuring line must touch the line being measured. This incline is 4 units long. **Return to text.**⏎ 126.

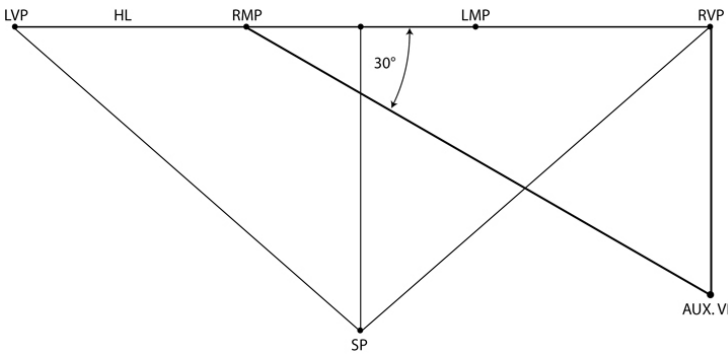


Figure 9.17 Finding the auxiliary vanishing point. **Return to text.**⏎

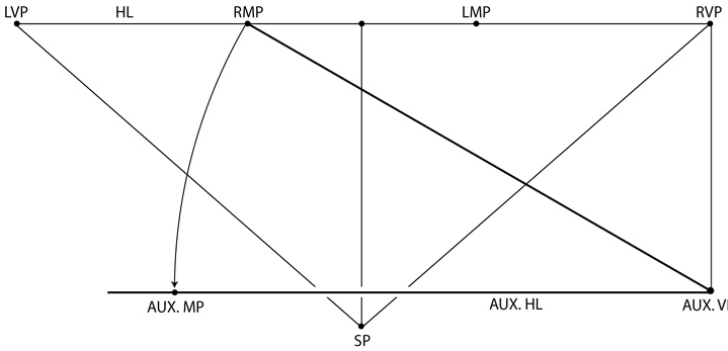


Figure 9.18 To find the auxiliary measuring point, measure the distance from the auxiliary vanishing point to the left measuring point, and transfer that distance to the auxiliary horizon line. **Return to text.**⏎

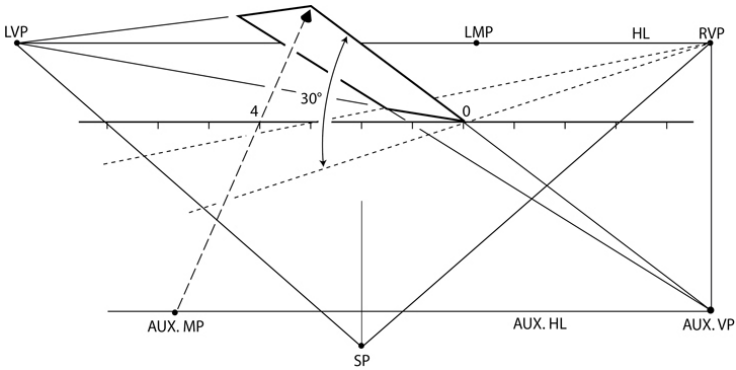


Figure 9.19 When measuring the slope, ensure the measuring line touches the line being measured. This incline is 4 units long. **Return to text.**⏎ 127.

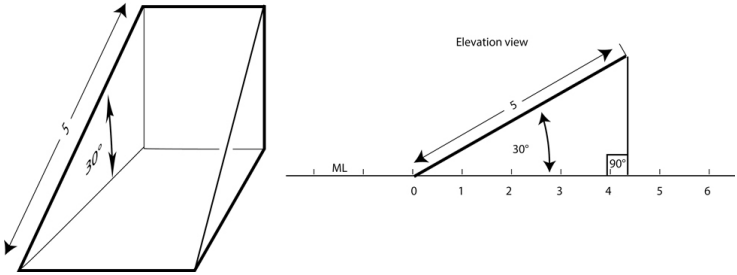


Figure 9.20 This incline is a right-angled triangle. Its hypotenuse is 5 units long, angled 30° from the horizontal leg. **Return to text.**⏎

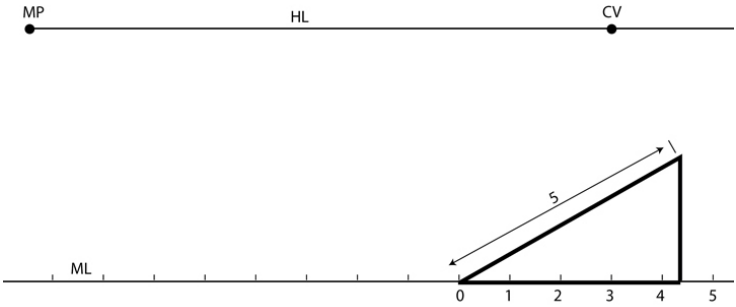


Figure 9.21 First draw an elevation view parallel to the picture plane using true dimensions and the true angle of the incline. **Return to text.**↵

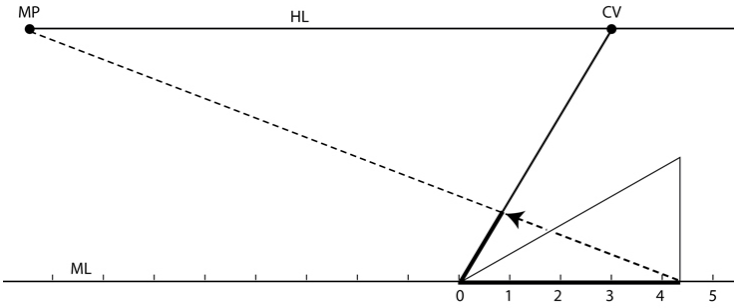


Figure 9.22 Transfer the horizontal leg in perspective. **Return to text.**↵

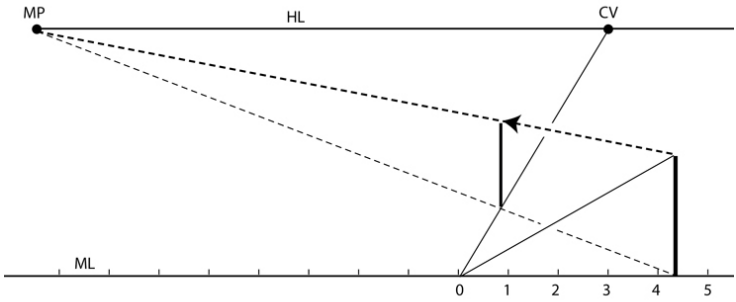
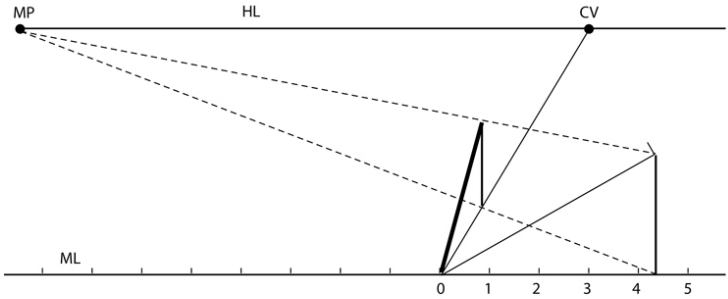


Figure 9.23 Transfer the vertical line in perspective. **Return to text.**↵



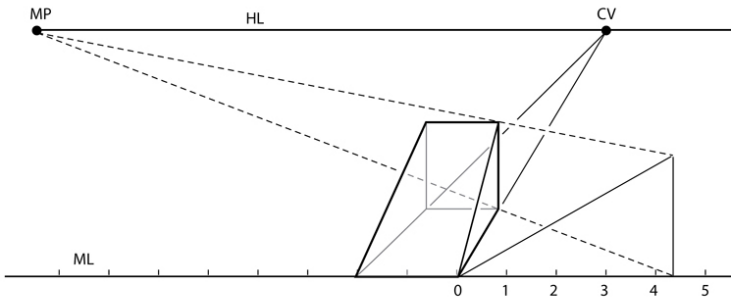
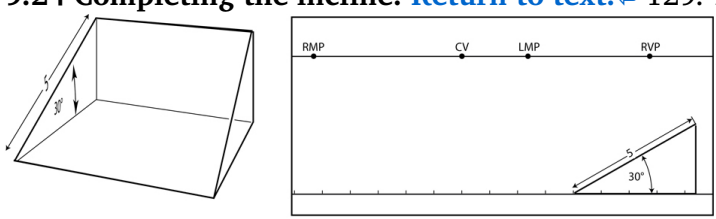
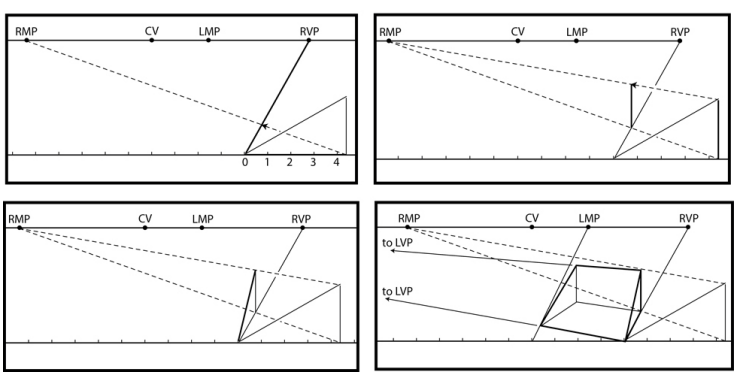


Figure 9.24 Completing the incline. Return to text.⏎ 129. 130.





Figure

9.25 Projecting the dimensions of an elevation view to a perspective view is an alternative method to draw two-point inclines. **Return to text.**⏎

chapter 9
Inclined Planes

DOI: 10.4324/9781003488101-15

112. Inclines continued to challenge artists long after the foundations of perspective had been established. When artists discovered that foreshortened lines connect to vanishing points *on* the horizon, it was a difficult concept to shed. Artists who attempted to draw inclines using points on the horizon line were met with curious results. The shapes looked tapered (Figure 9.1). This outcome made it obvious that something was amiss. Eventually it was reasoned that inclines connect to points *above* or *below* the horizon. Vanishing points on the horizon line draw lines parallel to the ground plane. Vanishing points above or below the horizon line draw lines at an angle to the ground plane.

One-Point Inclines

There are two types of one-point inclines: angles that are foreshortened (lines that are not parallel to the picture plane) and angles that are foreshortened (lines that are parallel to the picture plane). Angles parallel to the picture plane have no vanishing point. They are drawn as true angles (Figure 9.2). These are the simplest, yet the most deceiving, as many erroneously attempt to locate a vanishing point where none exists.

113. 114. Lines angling toward or away from the viewer are

foreshortened. These angles have vanishing points. These vanishing points are located above or below the horizon line and are called auxiliary vanishing points (AUX VPs). One-point perspective auxiliary vanishing points are aligned vertically with the center of vision (Figure 9.3).

Upward Inclines

Whether a slope angles up or down depends on the point of view. If standing at the top of the slope, the incline angles down. If standing below, the incline angles up. Inclines with auxiliary vanishing points above the horizon line are referred to as upward angles and inclines with auxiliary vanishing points below the horizon line as downward inclines (Figure 9.3).

The farther away the auxiliary vanishing point is from the horizon line, the steeper the incline. To draw an incline at a specific degree, a point for true angles is needed.

Vanishing Point

True angles for horizontal lines are found at the station point. The station point is used for angles parallel to the ground plane. Inclines can't use the station point. True angles for inclines are found at the measuring point. Any angle drawn at the measuring point creates an auxiliary vanishing point that draws that same angle in perspective. For example, if the desired slope is 30°, use a 30° angle at the measuring point. Extend that angle until it intersects a point directly above (or below, depending on the incline) the center of vision (Figure 9.4–5).

Auxiliary Measuring Point

To measure the incline requires a measuring point. Geometry determines its placement. From the auxiliary vanishing point, draw a horizontal line. This line is called an auxiliary horizon line (AUX HL). The auxiliary horizon line functions as a placeholder for the measuring point. The auxiliary measuring point is placed on this line.

Measure the distance from the auxiliary vanishing point to the one-point measuring point. Transfer that distance to the auxiliary horizon line (Figure 9.6).

Measuring the Incline

There is an important difference between measuring a line parallel to the ground plane and measuring a line angled to the ground plane. When measuring inclines, the measuring line must touch the line being measured (Figure 9.7). The geometry required to measure lines will be incorrect if this requirement is not met (see Chapter 11). It is often necessary to use a reference point to reposition the measuring line.

Downward Inclines

Downward inclines have an auxiliary vanishing point below the horizon line. The steps are the same as upward inclines, except they are done upside down. Use the measuring point to establish the auxiliary vanishing point (Figure 9.8). Plot the auxiliary measuring point (Figure 9.9). Draw the incline (Figure 9.10). Measure the incline (Figure 9.11).

Two-Point Inclines

Auxiliary vanishing points are aligned with vanishing points on the horizon line. In two-point perspective there is a left and a right vanishing point. So, which one should be used? Is the auxiliary vanishing point aligned with the right vanishing point or the left vanishing point? It can be confusing. More choices mean more opportunities to make mistakes. Fortunately, when a mistake is made, it is usually obvious and the drawing looks amiss. When this happens, it is time to reevaluate the choices made. With practice, choosing the location of the auxiliary vanishing point becomes intuitive. Until that time, there are guidelines to assist in their selection.

Placement

Auxiliary vanishing points can be above or below the left or right vanishing point. As a guide, consider how inclines recede in space. Think about diminution. Things closer to the viewer are larger; things farther away are smaller. How forms behave in perspective gives important clues for correctly locating the auxiliary vanishing point (Figure 9.12).

Another helpful hint in locating the auxiliary vanishing point is to consider the incline's axis. If the axis of an incline connects to the left vanishing point, the auxiliary vanishing point must be above or below the *right* vanishing point. Conversely, if the axis of an incline is aligned with the right vanishing point, then the auxiliary vanishing point must be on the *left* side (Figure 9.13).

Practice drawing inclines until confident with the correct positioning of the auxiliary vanishing points. When comfortable that these points can be properly located, it is time to draw specific angles.

Upward Inclines

Once the proper location of the incline's vanishing point is determined, the next step is to find the incline's angle, or the degree of the slope.

Measuring points provide true angles for inclines. If the auxiliary vanishing point is above or below the right vanishing point, use the right measuring point to find the true angles. Conversely, if the auxiliary vanishing point is above or below the left vanishing point, use the left measuring point to find the true angles. For example, to draw a 30° incline that tilts up and to the right, draw a true 30° angle from the right measuring point (Figure 9.14).

Auxiliary Measuring Point

Establishing an auxiliary measuring point follows the same procedure used in one-point perspective. Create an auxiliary horizon line. Measure the distance between the auxiliary

vanishing point and the measuring point. Transfer that distance to the auxiliary horizon line (Figure 9.15).

Measuring Line

As with all inclines, the measuring line must touch the line being measured (Figure 9.16).

Downward Inclines

Downward inclines are approached the same as upward inclines. Do the same procedure upside down (Figures 9.17–19).

An Alternative Method

One-Point Inclines

Often, there are several methods to solve a perspective problem, each with its own advantages and disadvantages. Drawing steep inclines using auxiliary vanishing points can be inconvenient, as the vanishing and measuring points are often beyond the edge of the paper. The following alternative method is not an elegant solution, but it does keep all the points on the paper.

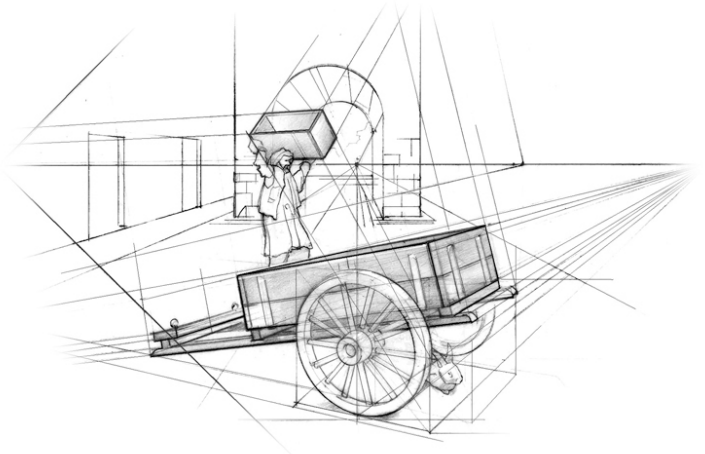
Any incline can be thought of as a right-angled triangle (a triangle with a 90° corner). This right-angled triangle has a horizontal, a vertical leg. The hypotenuse of the triangle is the incline (Figure 9.20).

In this alternative method, first draw an elevation view of the incline. This elevation view has no perspective. It is drawn to scale, using true dimensions (Figure 9.21).

128. The next step is to transfer the dimensions of the elevation view into a perspective view. Use a measuring point to transfer the length of the horizontal leg to a foreshortened line (Figure 9.22). Use the same measuring point to transfer the height of the vertical leg into position (Figure 9.23). Connect the ends of the two legs to create the incline (Figure 9.24).

Two-Point Inclines

Using the alternative method in two-point perspective follows the same basic procedures as one-point, the difference being that the right or left vanishing point is used instead of the center of vision. Draw the incline in an elevation view, and then project those dimensions to a perspective view (Figure 9.25).



131.

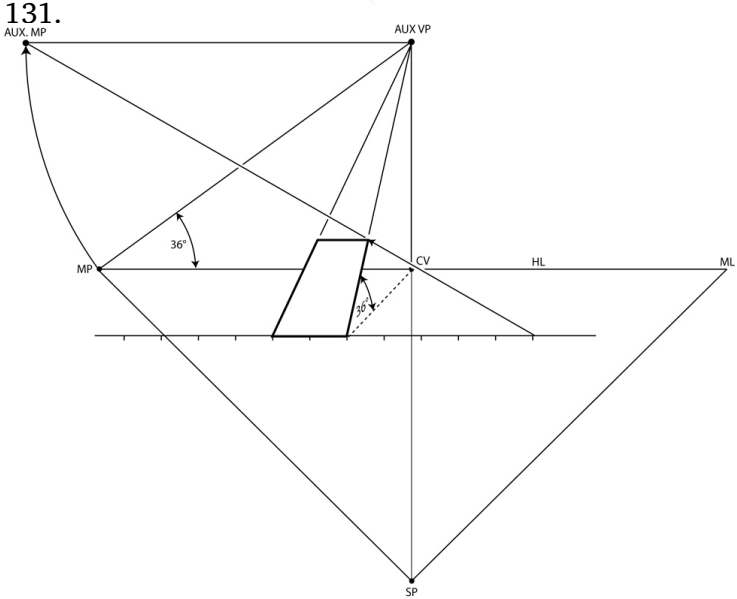


Figure 10.1 A one-point perspective inclined plane, 2 units wide, 5 units long, at a 36° incline. **Return to text.**⏎ 133.

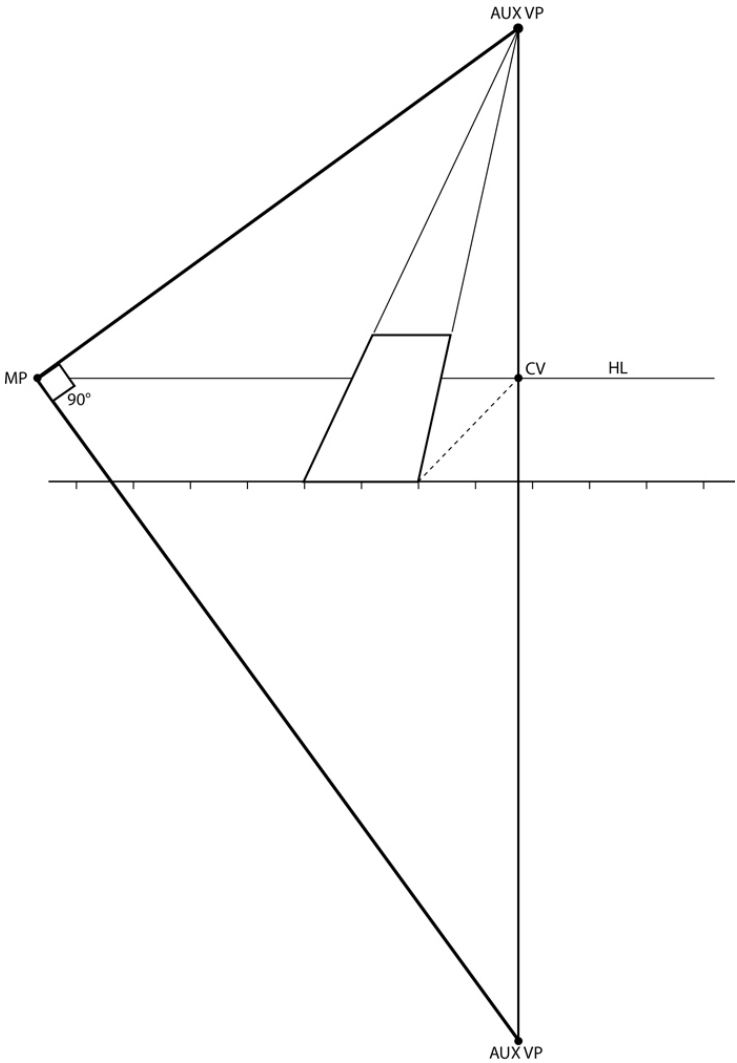


Figure 10.2 The upper and lower auxiliary vanishing points are 90˚ apart at the measuring point. **Return to text.**⏎

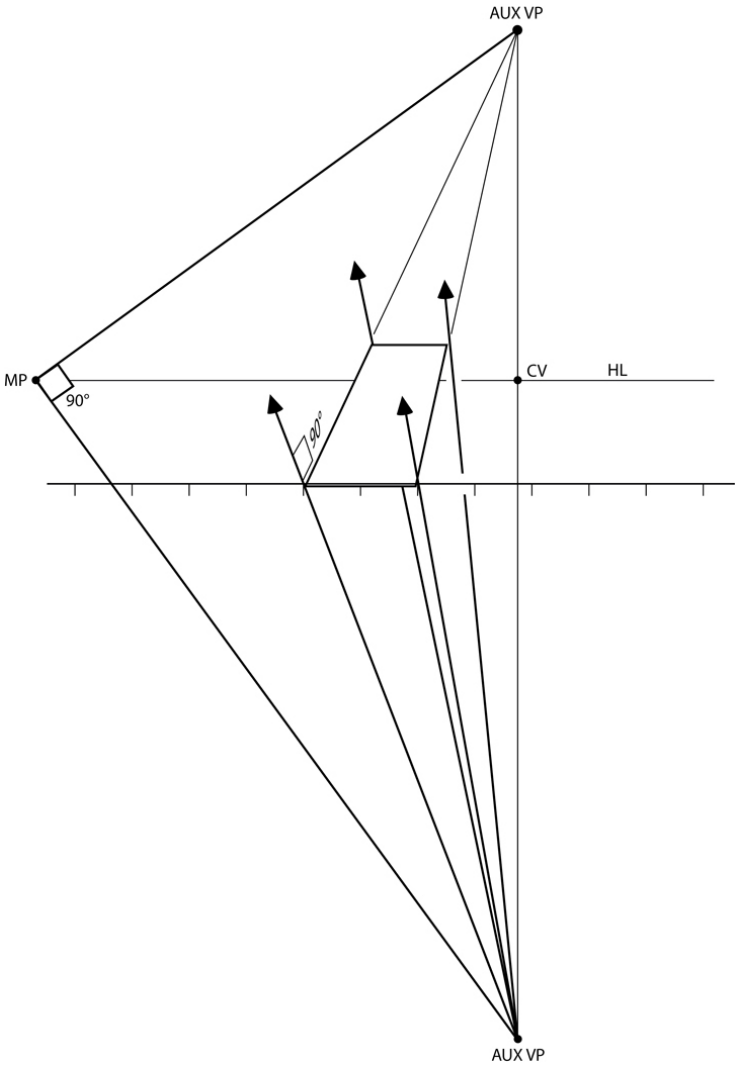


Figure 10.3 Lines drawn from the lower auxiliary vanishing point are right angles to lines drawn from the upper auxiliary vanishing point. **Return to text.**⏎ 135.

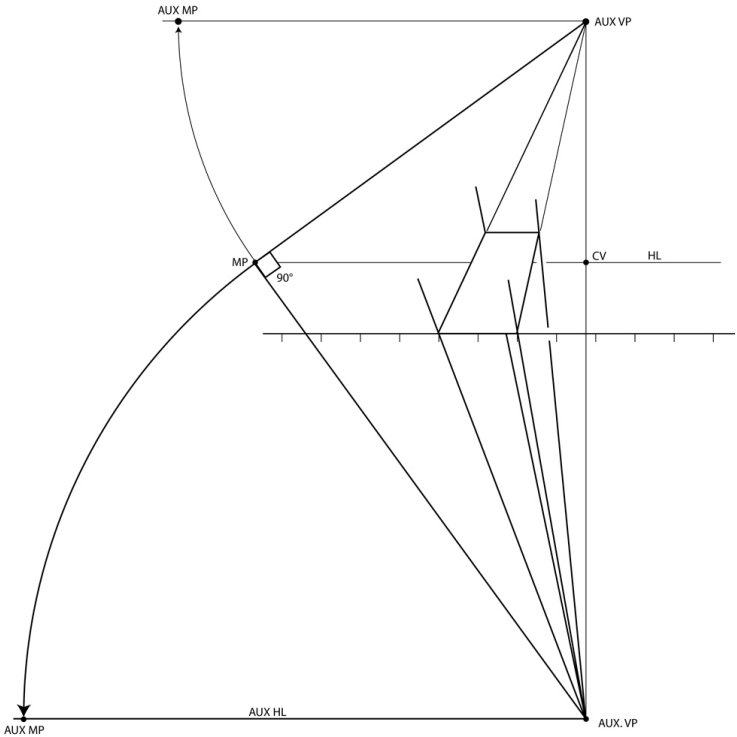


Figure 10.4 The distance from the auxiliary vanishing point to the measuring point is the same as the distance from the auxiliary vanishing point to the auxiliary measuring point.
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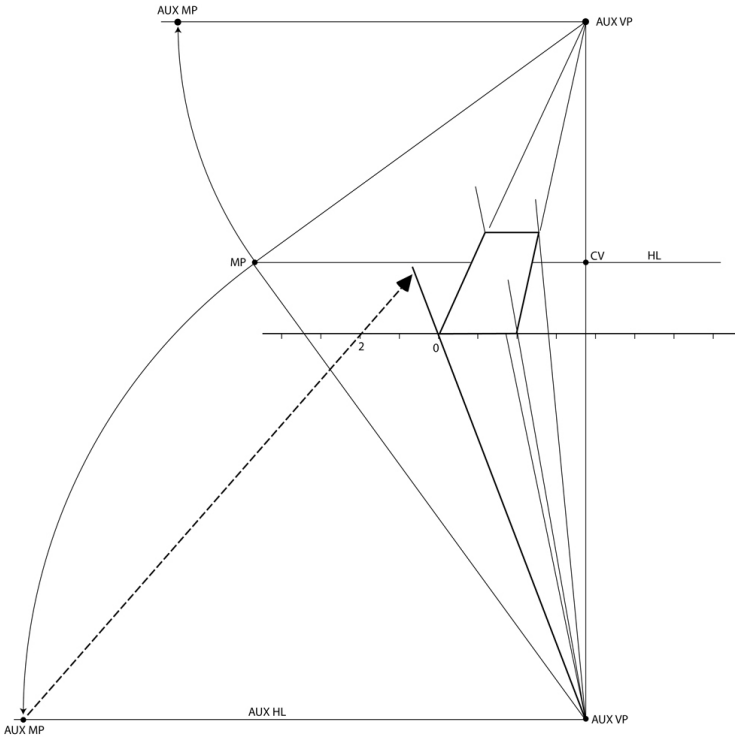

Figure 10.5 Position the measuring line so that it touches the line being measured. This illustration shows a length of 2 units.
Return to text.⏎ 136. 137.

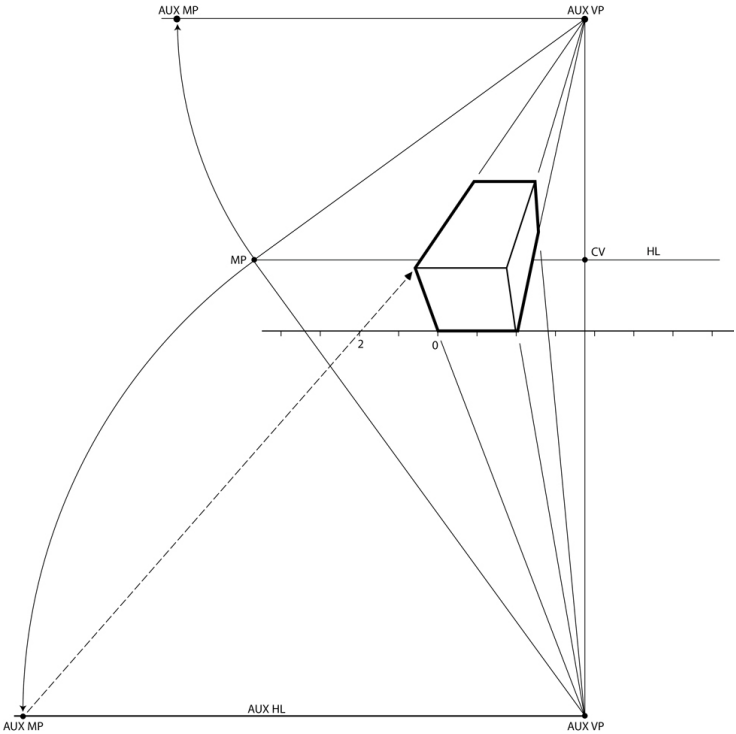

Figure 10.6 Connect lines to vanishing points to complete the box.
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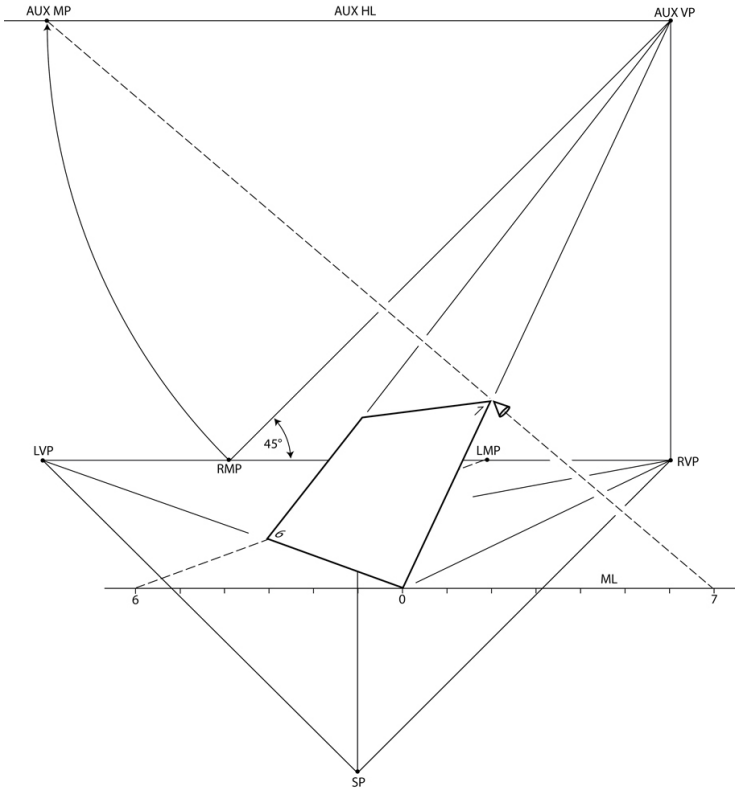


Figure 10.7 The starting point is a two-point perspective inclined plane. It is 6 units wide and 7 units long, tilting up from the ground plane at 45°. **Return to text.**⏎ 139.

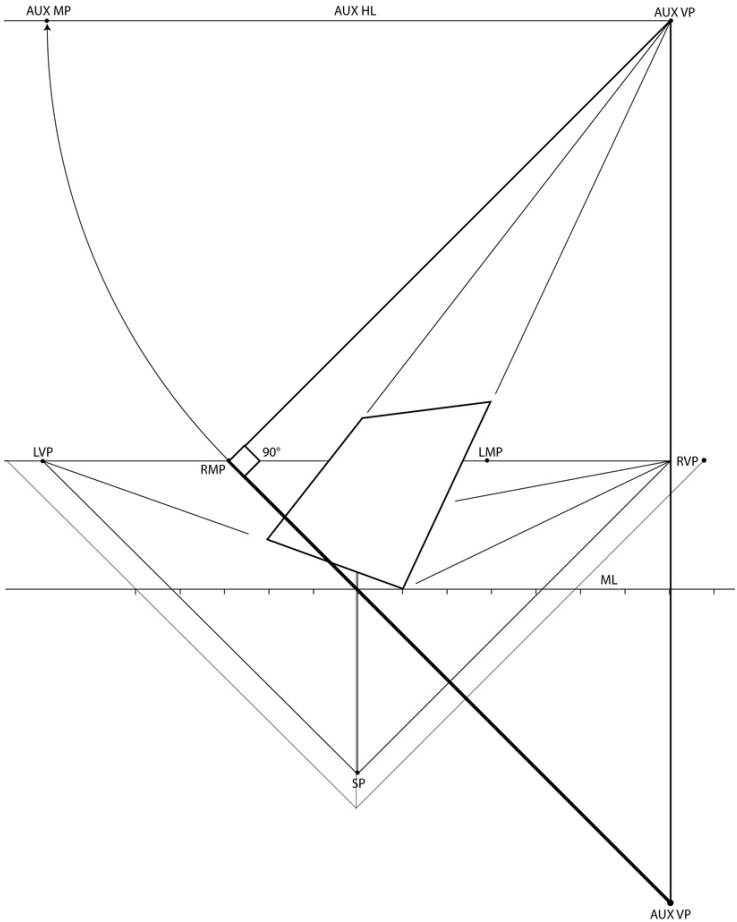


Figure 10.8 A right angle at the measuring point creates two auxiliary vanishing points 90° apart. **Return to text.**⏎

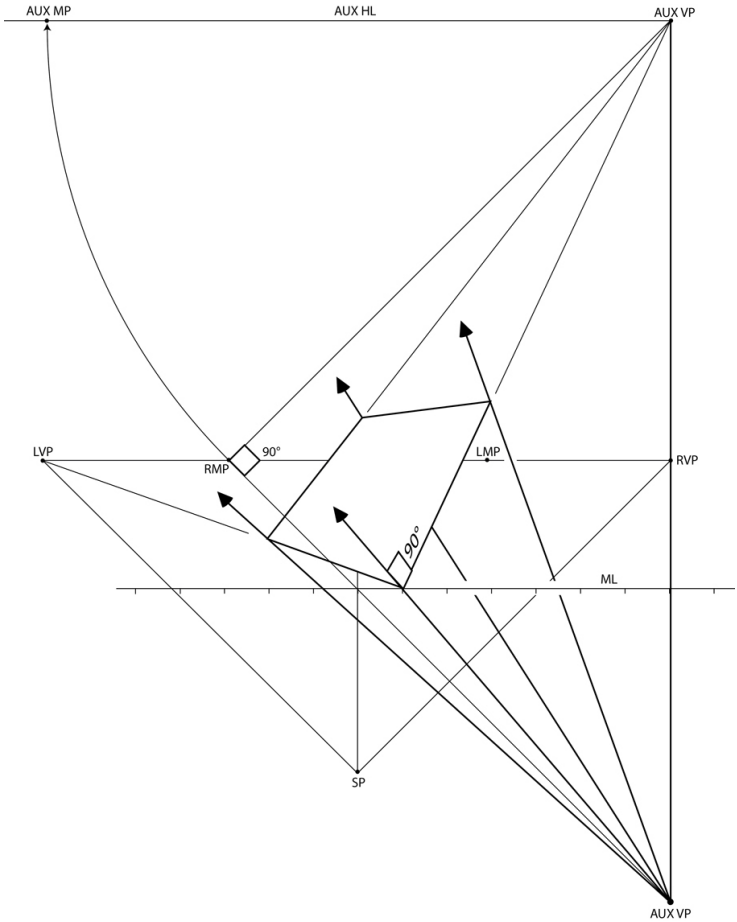


Figure 10.9 Project lines from the lower auxiliary vanishing point to create 90˚ corners. **Return to text.**⏎ 140. 141.

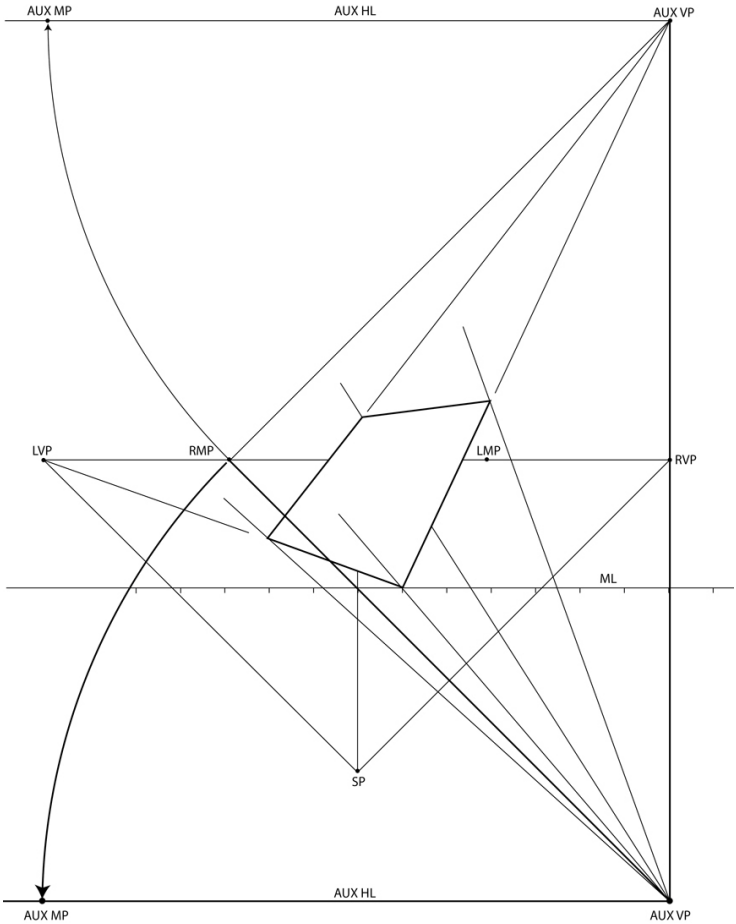


Figure 10.10 Measure the distance from the auxiliary vanishing point to the measuring point and transfer that distance to the auxiliary horizon line. **Return to text.**⏎

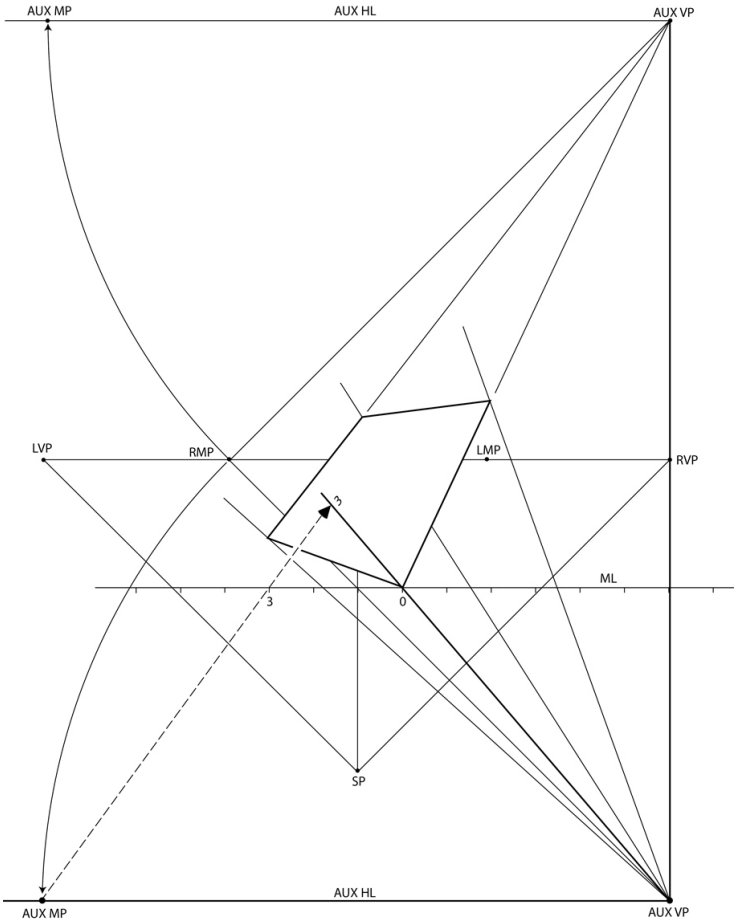


Figure 10.11 The measuring line must touch the line being measured. This example shows a length of 3 units. **Return to text.**⏎ 142. 143.

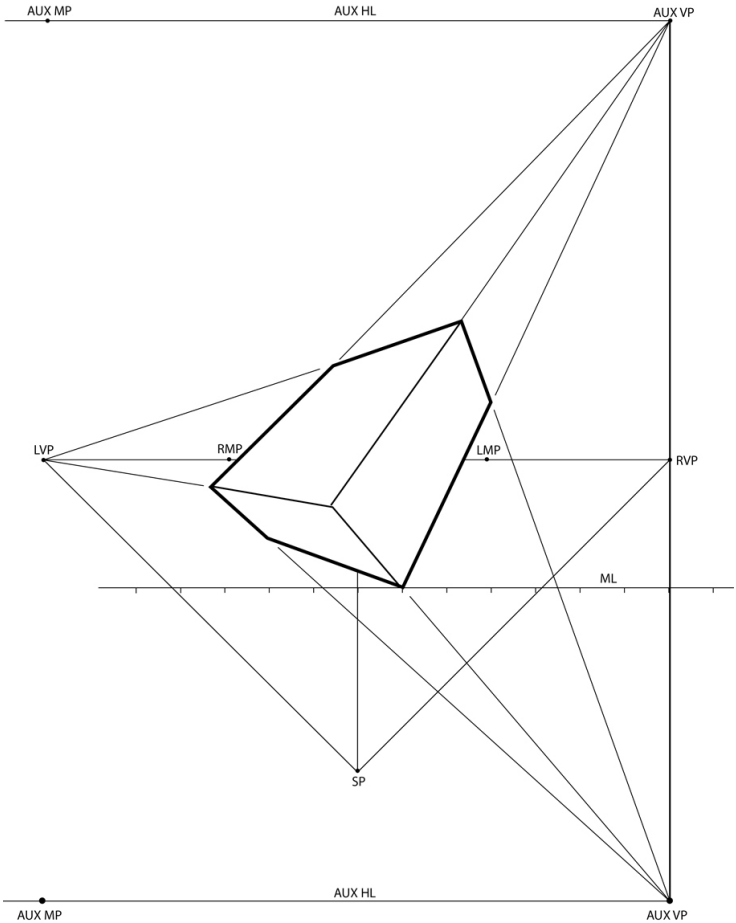


Figure 10.12 Connect lines to vanishing points to complete the box. **Return to text.**⏎

chapter 10
Inclined Cuboids

DOI: 10.4324/9781003488101-16

132. The previous chapter outlined the procedures to draw an

inclined plane. A plane has only two dimensions. This chapter adds the missing dimension. This chapter begins where Chapter 9 left off. As such, it is helpful to have a good understanding of inclined planes before progressing to drawing inclined cuboids.

One-Point Perspective

Draw a one-point perspective inclined plane (Figure 10.1). See Chapter 9 for step-by-step instructions.

Auxiliary Vanishing Point

A third dimension is extruded from this inclined plane. All the corners are right angles. The thickness projects 90° from the inclined plane. To draw the thickness, another auxiliary vanishing point is needed, a point 90° from the original auxiliary vanishing point. Thus, the first step is to locate the point of true angles—the measuring point. At the measuring point, draw a 90° angle from the original auxiliary vanishing point. There are now two auxiliary vanishing points that are 90° apart (Figure 10.2).

134. Any line drawn from the lower auxiliary vanishing point will create a 90° angle to any line drawn from the upper auxiliary vanishing point (Figure 10.3).

Measuring the Thickness

Establish measuring points as described in Chapter 9 (Figure 10.4). Remember, the measuring line must touch the line being measured (Figure 10.5).

Completing the Box

Connect the lines to the proper vanishing points to complete the box (Figure 10.6).

Inclined Two-Point Cuboids

Draw a two-point perspective inclined plane (Figure 10.7). See

Chapter 9 for step-by-step instructions.

Auxiliary Vanishing Points

Angled cuboids have three vanishing points: two auxiliary vanishing points and one vanishing point located on the horizon line. The auxiliary vanishing points are always aligned vertically. They are above and below the left *or* right vanishing point.

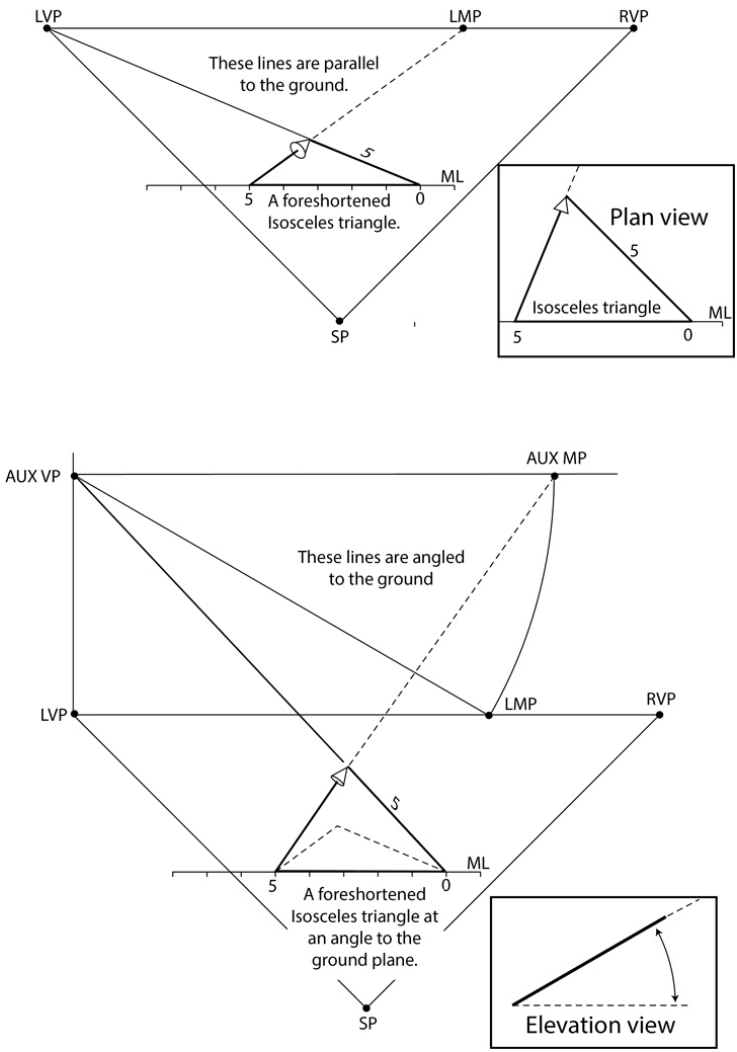
To draw 90° corners, the auxiliary vanishing points must be 90° apart. True angles for inclines are found at the measuring point. Inclines to the left use the left measuring point, and inclines to the right use the right measuring point (Figure 10.8). A right angle drawn at the measuring point creates auxiliary vanishing points that draw right angles in perspective (Figure 10.9).

Measuring Point

Establish the auxiliary measuring point using the procedure outlined in Chapter 9 (Figure 10.10). Measure the desired thickness of the box. Make sure the measuring line touches the line being measured (Figure 10.11).

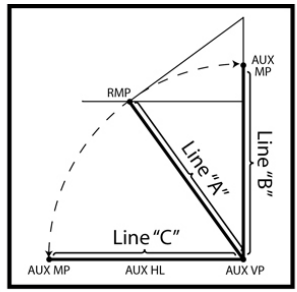
Complete the Box

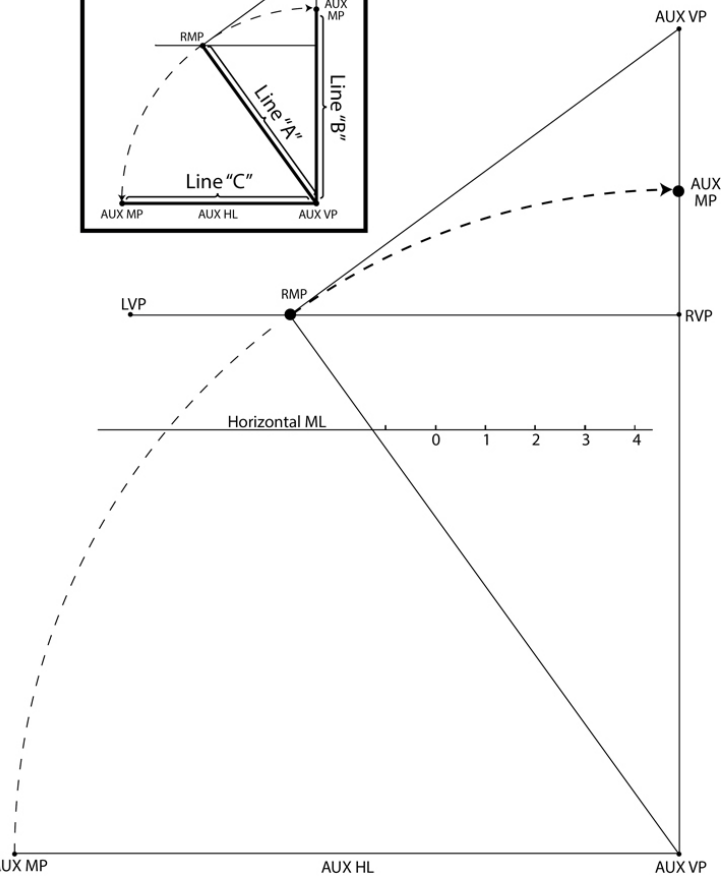
Connect lines to appropriate vanishing points to complete the box (Figure 10.12).



144.

Figure 11.1Measuring points located on the horizon line create isosceles triangles parallel to the ground plane (top). Auxiliary measuring points create isosceles triangles at an angle to the ground plane (bottom). **Return to text.**⏎ 146.





147. **Figure 11.2 The auxiliary measuring point can be on a vertical line as well as a horizontal. The distance from the measuring point to the auxiliary vanishing point (Line "A") must be the same as the distance from the auxiliary vanishing point to the auxiliary measuring point (Line "B" or "C").** **Return to text.**⏎

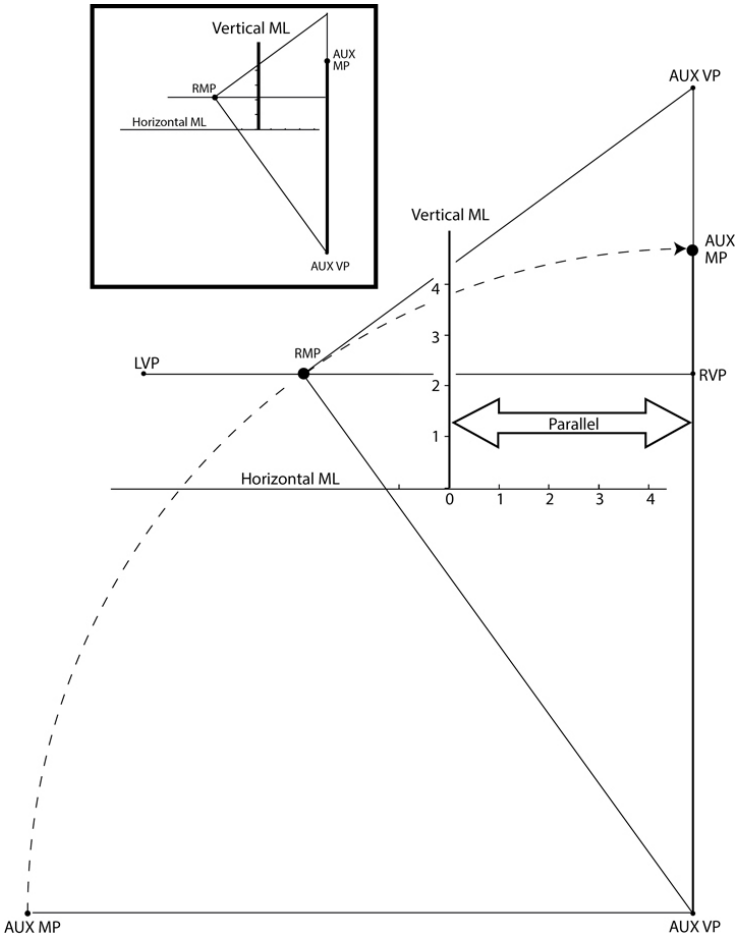


Figure 11.3 The measuring line must be parallel with the line the measuring point is on. If the measuring point is on a vertical line, the measuring line must also be vertical.
Return to text.⏎

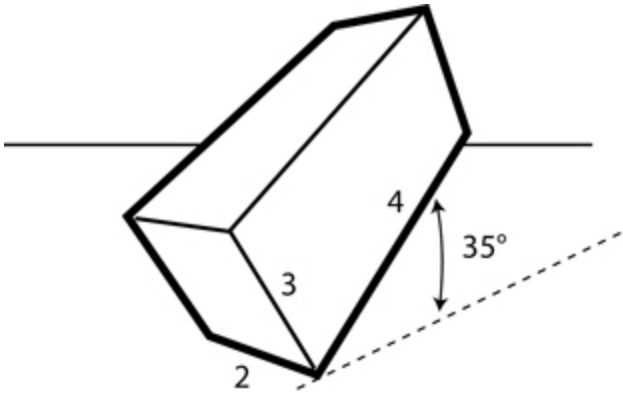


Figure 11.4 A box measuring 3 units high, 4 units wide, and 2 units deep at a 35° incline. **Return to text.**⏎

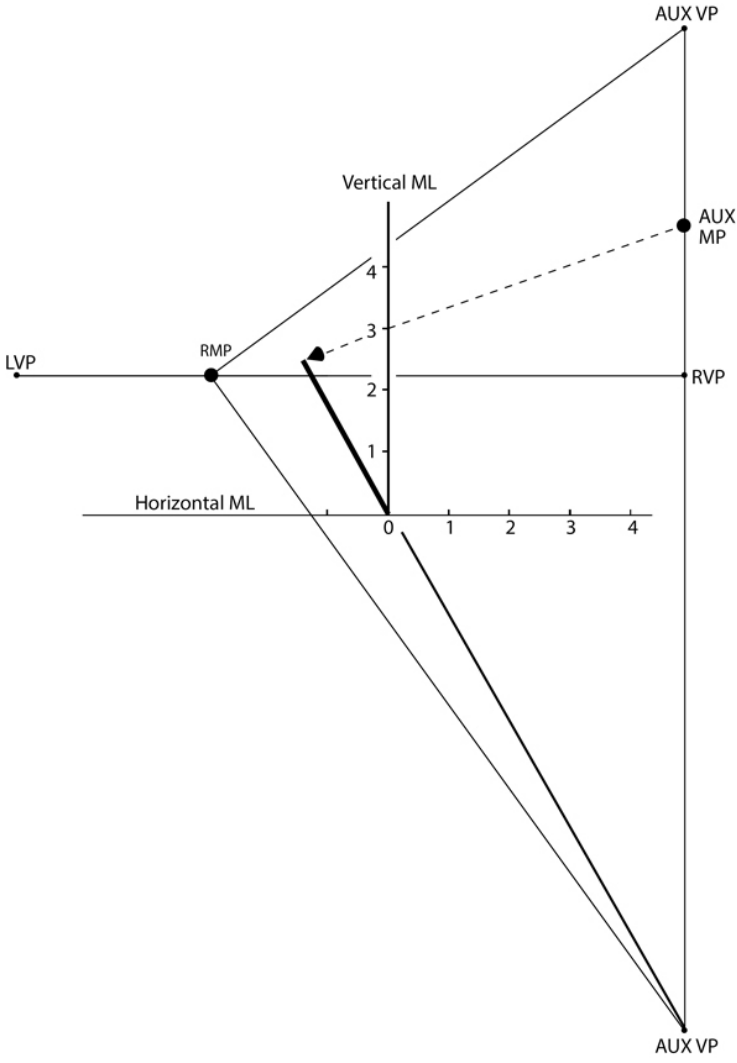


Figure 11.5 Using a vertical measuring point and a vertical measuring line to measure a 3-unit length. **Return to text.**⏎

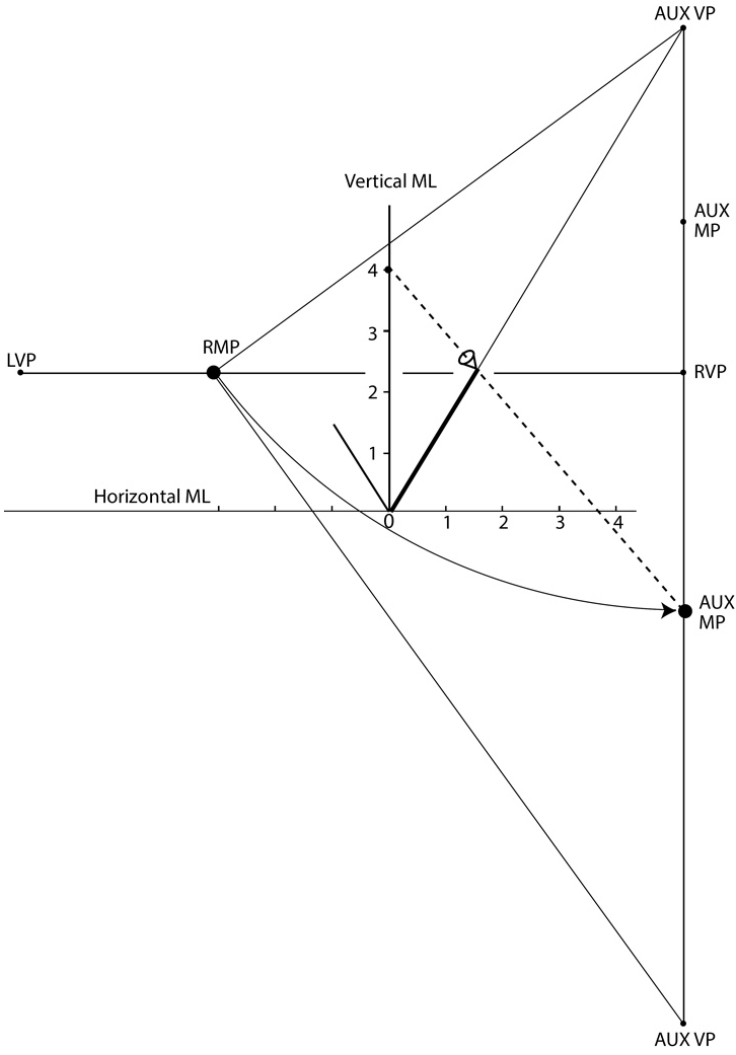
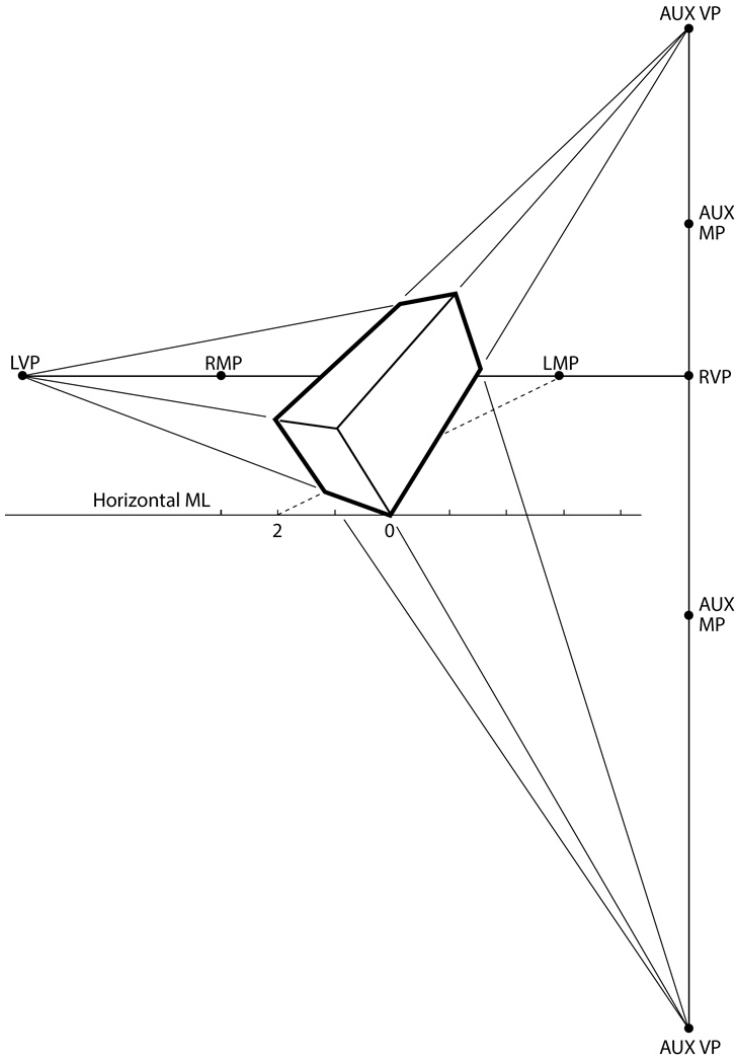


Figure 11.6 Using a vertical measuring point and a vertical measuring line to measure a 4-unit length. **Return to text.**⏎



150.

Figure 11.7 Connect corners to vanishing points to complete the box. Use the horizontal measuring line to measure the depth (2 units). **Return to text.**⏎ 151. 152.

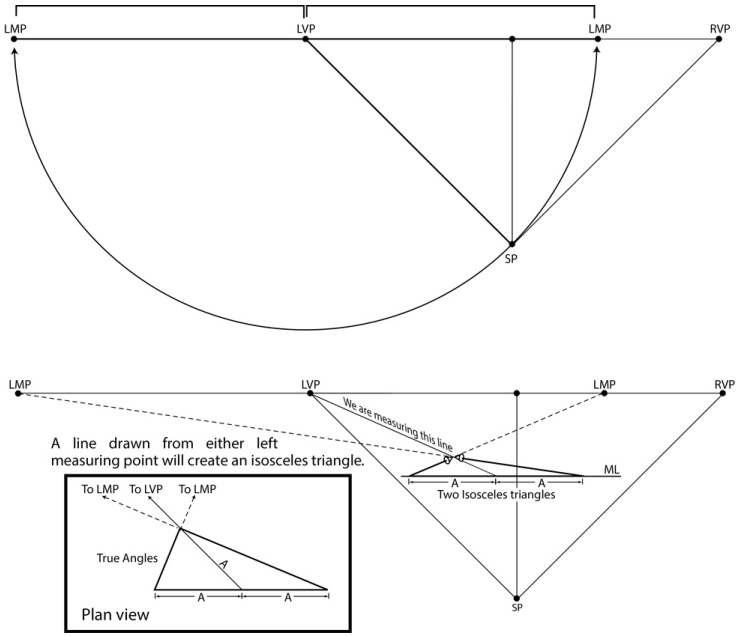


Figure 11.8 The measuring point can be placed to the right or the left of the vanishing point. Both measuring points draw isosceles triangles. Both can be used to measure lines that connect to the left vanishing point. **Return to text.**⏎

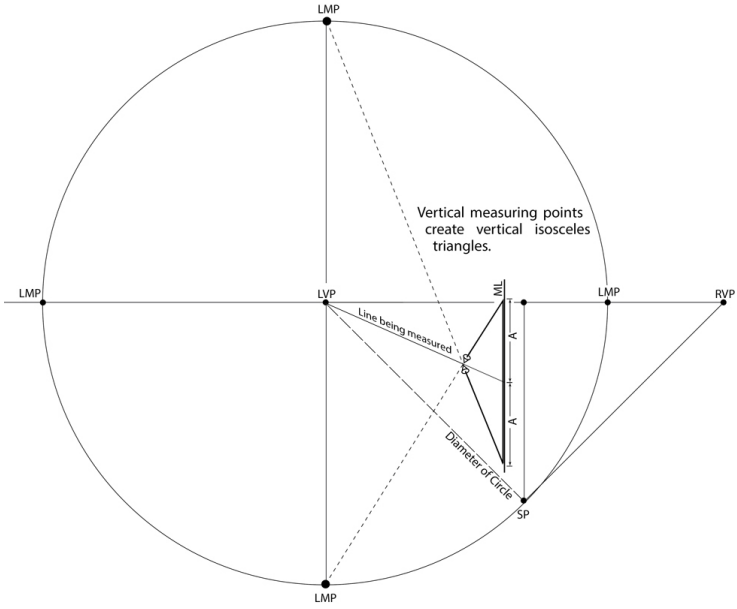


Figure 11.9 Measuring points can be on a vertical line, but the

measuring line must also be vertical. Return to text.⏎ 153.

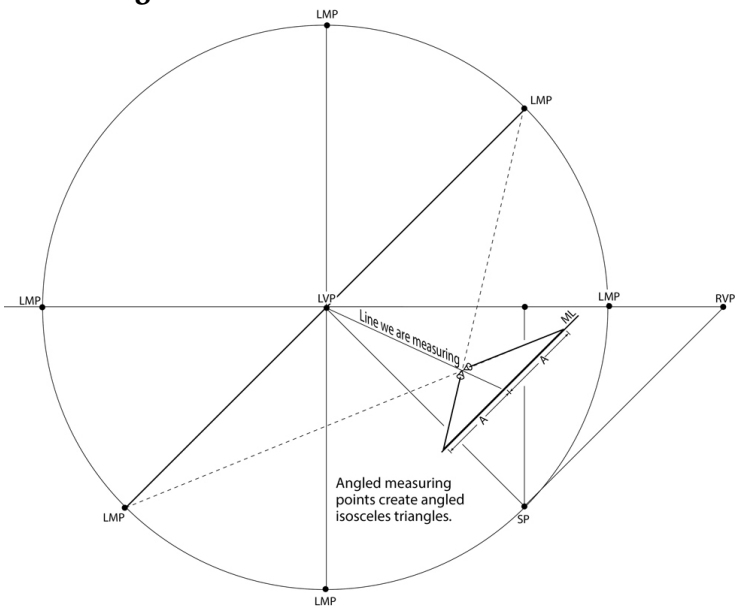


Figure 11.10 Measuring points can be on a diagonal line if the measuring line is at the same angle. Return to text.⏎ 154.

chapter 11
Incline Geometry

DOI: 10.4324/9781003488101-17

145. Chapter 6 explored the geometry of measuring points, the importance of isosceles triangles, and how measuring points draw isosceles triangles in perspective. Auxiliary measuring points also draw isosceles triangles, the only difference being that the isosceles triangle is at an incline. If the line being measured is parallel to the ground plane, the isosceles triangle is also parallel to the ground plane (Figure 11.1, top). If the line being measured is inclined, the isosceles triangle is also inclined

(Figure 11.1, bottom).

It has been stated several times that when measuring inclines, the measuring line must touch the line being measured. This, however, is not the case when measuring lines parallel to the ground plane. Why the aberration?

Lines drawn from auxiliary vanishing points are angled to the ground plane. Likewise, lines drawn from auxiliary measuring points are also angled to the ground plane. Lines drawn from the auxiliary measuring point would, if extended, follow a path *underground*. If the measuring line did not touch the line being measured, the line projected from the auxiliary measuring point would never contact the measuring line. Because of this, it is necessary for the measuring line to be in a very specific location —touching the line being measured (Figure 11.1). If the measuring line is not already touching the line being measured, the measuring line must be moved so that it does.

Vertical Auxiliary Measuring Points

In previous examples, the auxiliary measuring point was placed on an auxiliary horizon line (Figure 11.2, line "C," inset). Yet auxiliary measuring points do not *need* to be on the auxiliary horizon line; there are many places the measuring point can be sited. Often, the most convenient location is on a vertical line, the line connecting the two auxiliary vanishing points (Figure 11.2, line "B," inset). However, no matter its location, a measuring point must always draw isosceles triangles. For this to happen, the geometry must be correct. For the geometry to be correct, an important rule must be followed.

148. The relationship between a measuring point and the measuring line is critical. For a measuring point to draw an isosceles triangle, the measuring line must be parallel to the line the measuring point is on. If the measuring point is on a horizontal line (e.g., the horizon line, or the auxiliary horizon line) the measuring line must also be horizontal. If the measuring point is on a vertical line, the measuring line must also be vertical (Figure 11.3).

149. The primary advantage of placing the measuring point on a vertical line is its proximity. Inclines often lead to points beyond the page's border. If the auxiliary vanishing point is off the page, the auxiliary measuring point will be even farther away. Placing the measuring point on a vertical line keeps the measuring points close at hand.

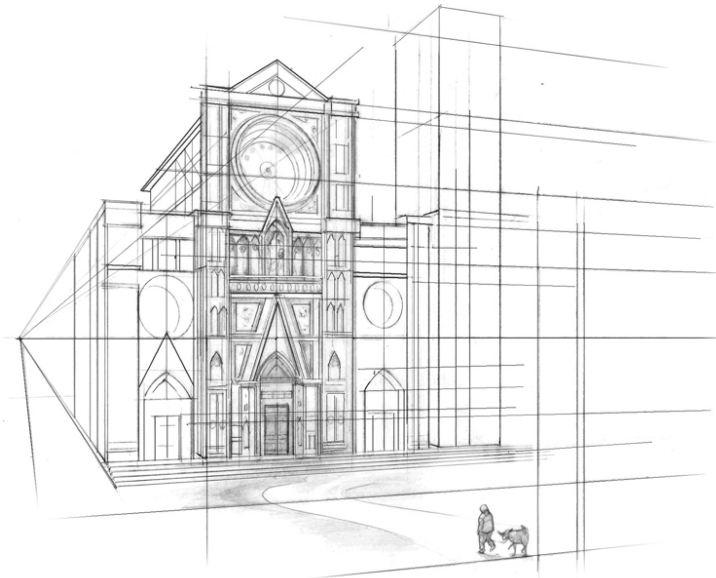
To demonstrate this, draw a box that is 3 units tall, 4 units wide, and 2 units deep, inclined at a 35° angle (Figure 11.4).

Using a vertical measuring point and vertical measuring line, measure the height and width (Figure 11.5–6). Then connect the lines to the appropriate vanishing points to complete the box (Figure 11.7).

More on Measuring Point Geometry

Measuring points can be on horizontal lines or vertical lines. These are the two most logical and practical locations. Placing them elsewhere is not advised—but it is possible.

The measuring point can be anywhere, if two crucial rules are adhered to: 1) the measuring point must be the same distance from the vanishing point as the vanishing point is from the station point; 2) the measuring line must be parallel to the line the measuring point is on. If these two rules are followed, the measuring point will draw an isosceles triangle (Figures 11.8–10).



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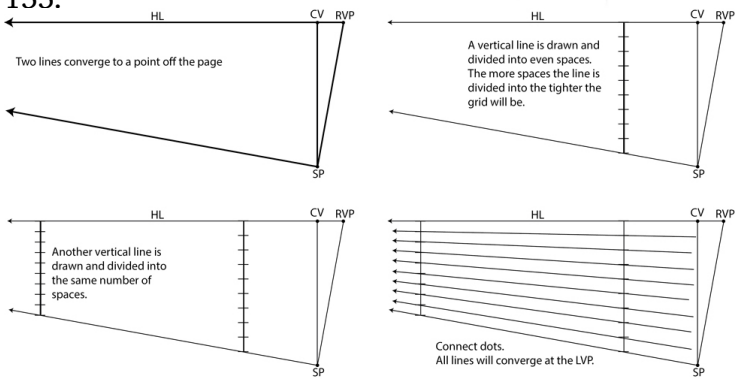

Figure 12.1 Creating a grid to find a vanishing point off the page.

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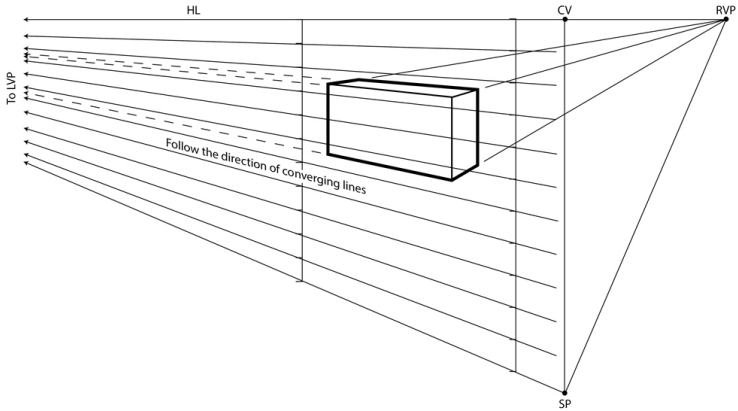

Figure 12.2 Drawing a box using the grid. The grid creates a guide. Align the foreshortened lines of the object to the grid.
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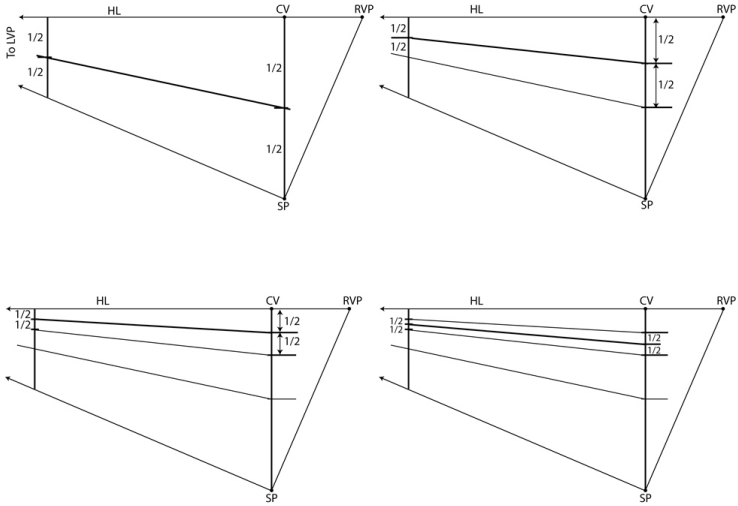

Figure 12.3 This shortcut is a fast and simple way to create a grid.
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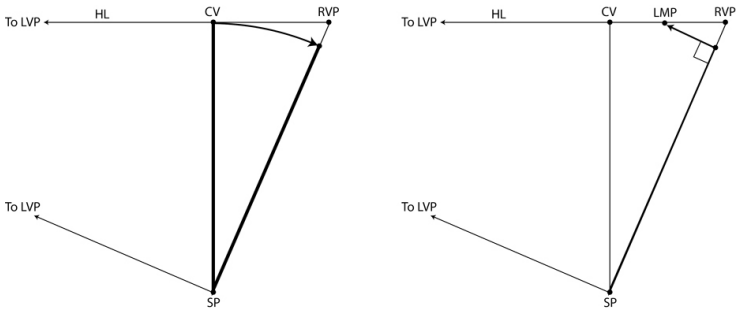


Figure

12.4 Finding a measuring point without using a vanishing point. **Return to text.**⏎ 159.

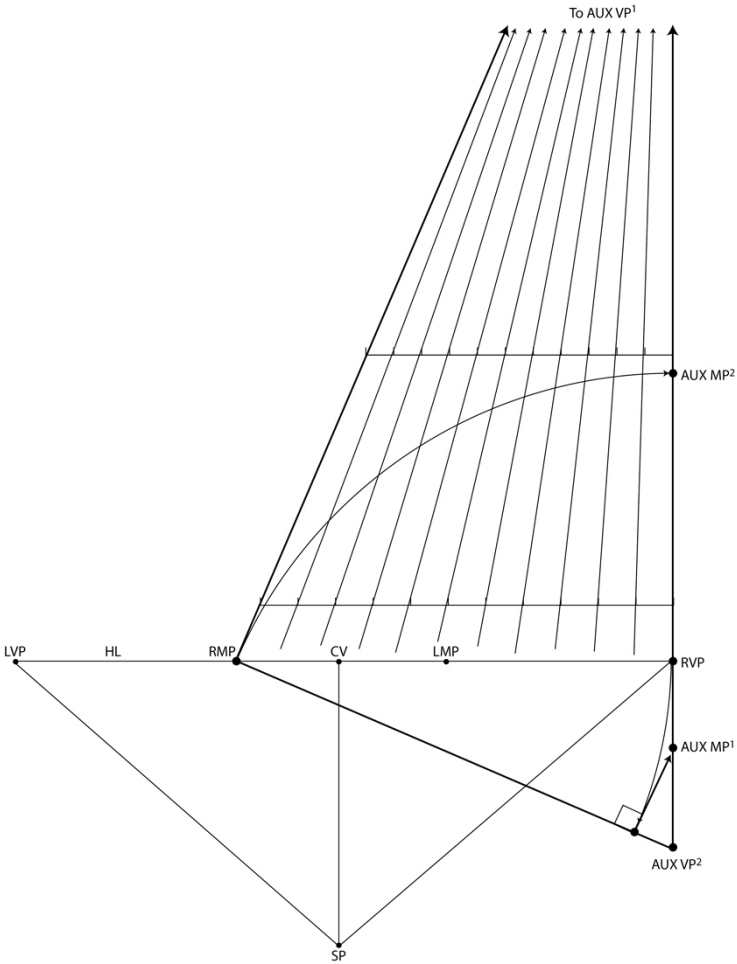


Figure 12.5 Using a grid to access a distant auxiliary vanishing point. The auxiliary measuring point is on a vertical line, so the measuring line will also need to be vertical. **Return to text.**⏎ 160.

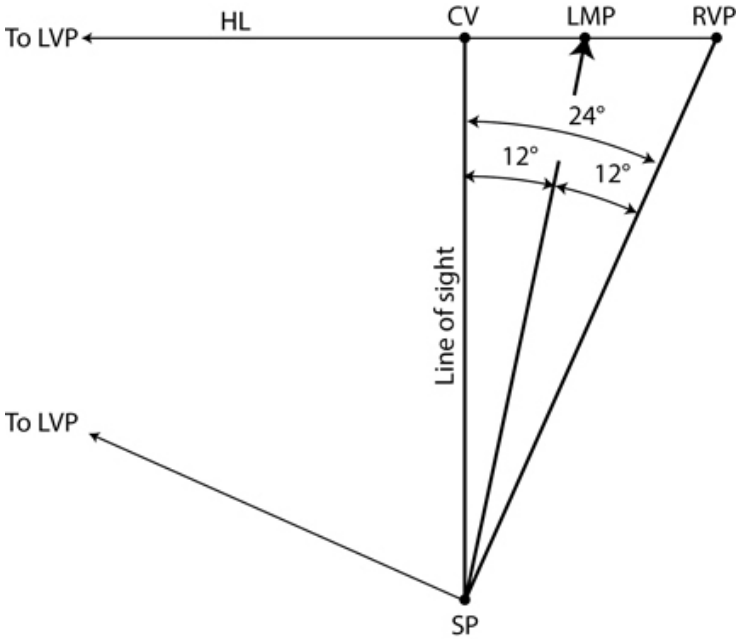


Figure 12.6 Using a protractor to find a measuring point. **Return to text.**⏎ 161.

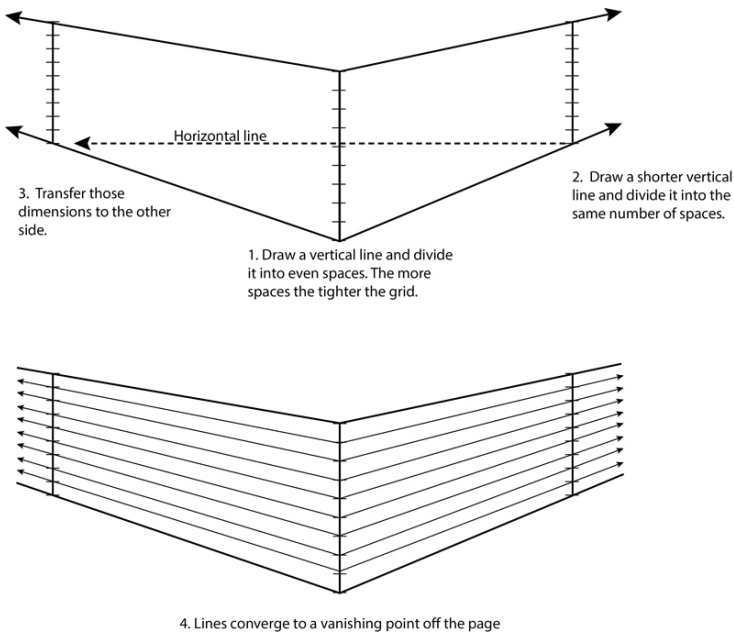


Figure 12.7 The Brewer method. **Return to text.**⏎

chapter 12
The Problem of Distant Vanishing Points

DOI: 10.4324/9781003488101-18

156. When plotting vanishing points, they can, from time to time, fall off the page, sometimes very far off the page. Before buying a very long desk and ruler and taping paper together end to end, there is another solution. It borrows a page from the grid approach to perspective.

The Grid Approach

If the vanishing point is off the page, create a grid of evenly spaced parallel lines that will lead to that distant point. This grid is a series of evenly spaced parallel lines that remain proportional as they recede.

From the station point draw a 90° angle, creating a left and right vanishing point. If one of the vanishing points is far off the page a grid can be made to guide the artist in drawing appropriate angles (angles that lead to the distant vanishing point). Divide the distance between the horizon line and the line from the station point into evenly spaced segments. The number of divisions used is at the artist's discretion. The more divisions, the tighter the grid (Figure 12.1). This grid serves as a guide to the distant vanishing point. Once the grid is in place, use it to gauge the direction of diminution. Create as fine a grid as needed to guide the drawing (Figure 12.2).

Shortcut

To save some time—and some lines—here is a shortcut. Instead of dividing the length of each line into a series of even spaces, divide the line in half. Continue to divide into halves until there

are enough lines to do the job. Often only a few lines are needed (Figure 12.3).

Measuring

Foreshortened lines are now able to be drawn without a vanishing point. Next, a way to measure those lines is required. But without the vanishing point, how is the measuring point located? There are a few solutions. This first method is a three-step process. First, measure the distance from the station point to the center of vision. Then transfer that distance to the line connecting the station point to the vanishing point. From this intersection, draw a right angle, projecting it to the horizon line (Figure 12.4).

Inclines

This method is useful when working with inclines, where the auxiliary vanishing point is often off the page. The procedure is the same, but the diagram is turned 90°. This method necessitates the auxiliary measuring point being on a vertical line (Figure 12.5).

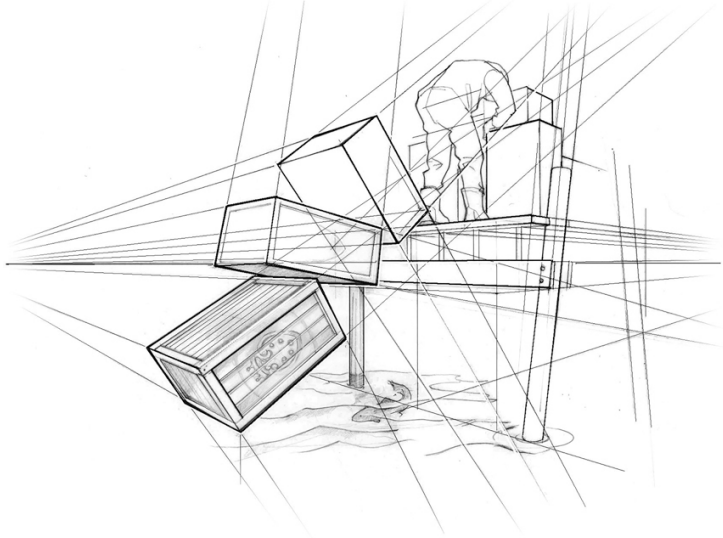
Using a Protractor

An alternative method to locating the measuring point is using a protractor. The measuring point is halfway (in degrees) between the center of vision and the vanishing point. For example, if the angle between the line of sight and the right vanishing point is 24°, then the measuring point is at 12° (Figure 12.6).

The Brewer Method

The Brewer method is a way to create a grid when both vanishing points are off the page. This is accomplished by duplicating the method discussed earlier in this chapter and placing it on the other side of the diagram (Figure 12.7). The Brewer method creates a grid of orthogonal lines that connect

to a distant vanishing point. Unfortunately, the station point is also off the page, so finding measuring points (which may also be off the page) becomes difficult. Because of this the dimensions of objects are often guessed at. Additionally, drawing objects that are not parallel with each other becomes problematic without the station point.



162.

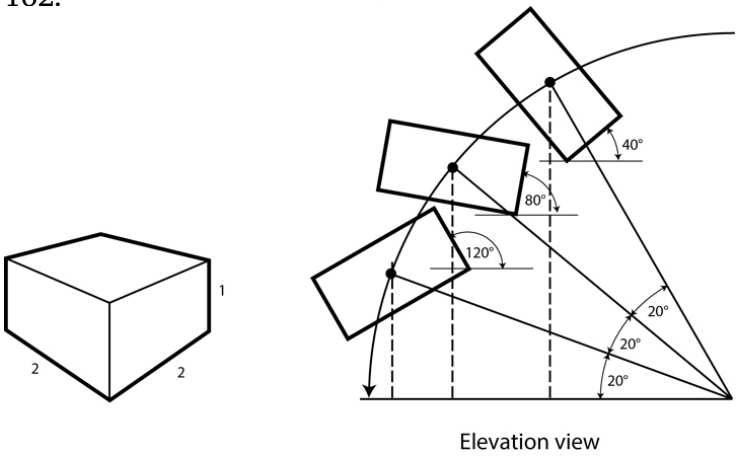


Figure 13.1 It is helpful to draw an elevation view of complicated scenarios. These are the angles and dimensions of the falling, rotating box. **Return to text.**⏎ 164.

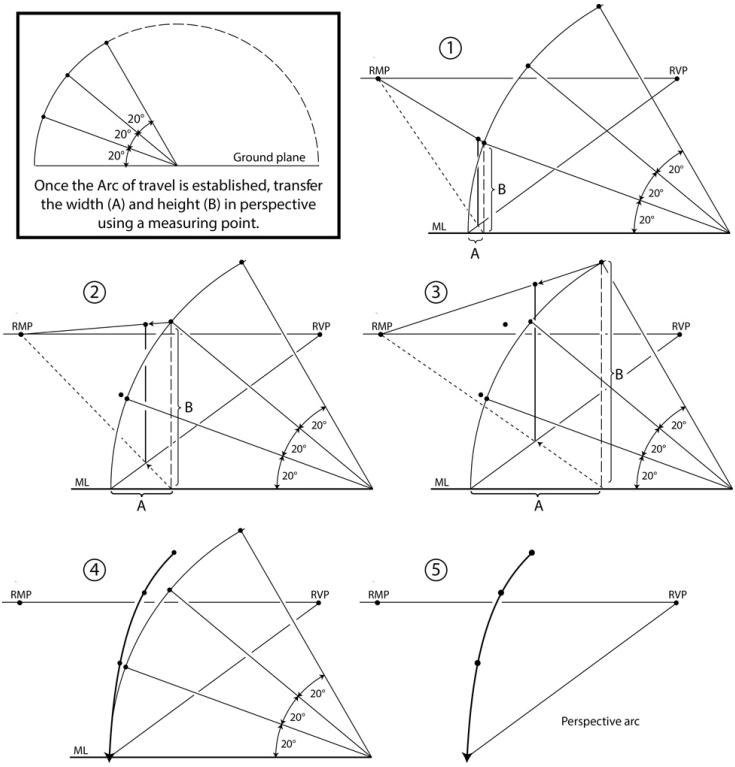


Figure 13.2 Drawing the arc of travel. The dots are 20° apart and represent the center point of each box. **Return to text.**⏎

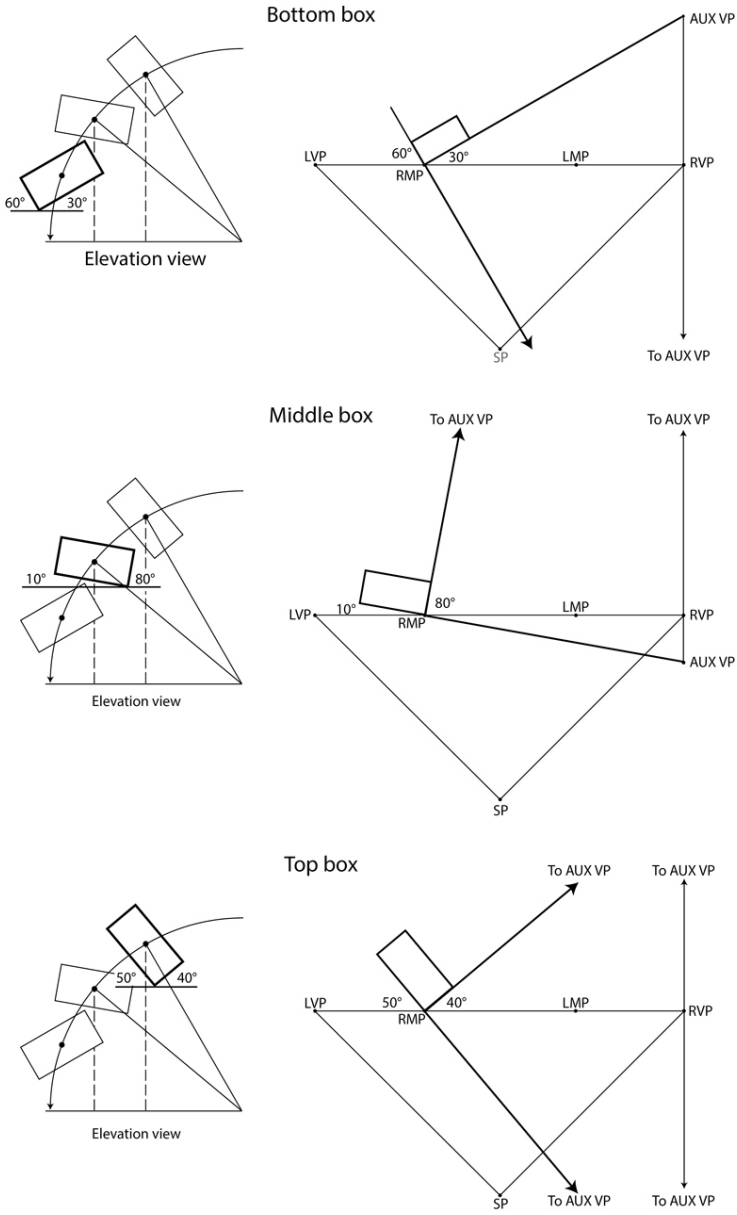


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Figure 13.3 Auxiliary vanishing point angles for each box.

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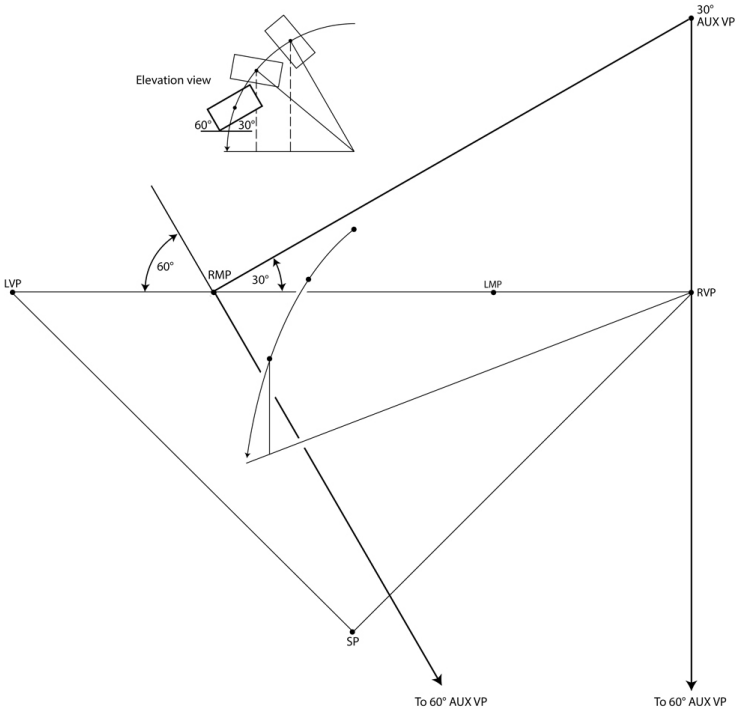

Figure 13.4 The box closest to the viewer is angled 60°/30° from the ground plane. Place those same angles at the measuring point. **Return to text.**⏎ 168.

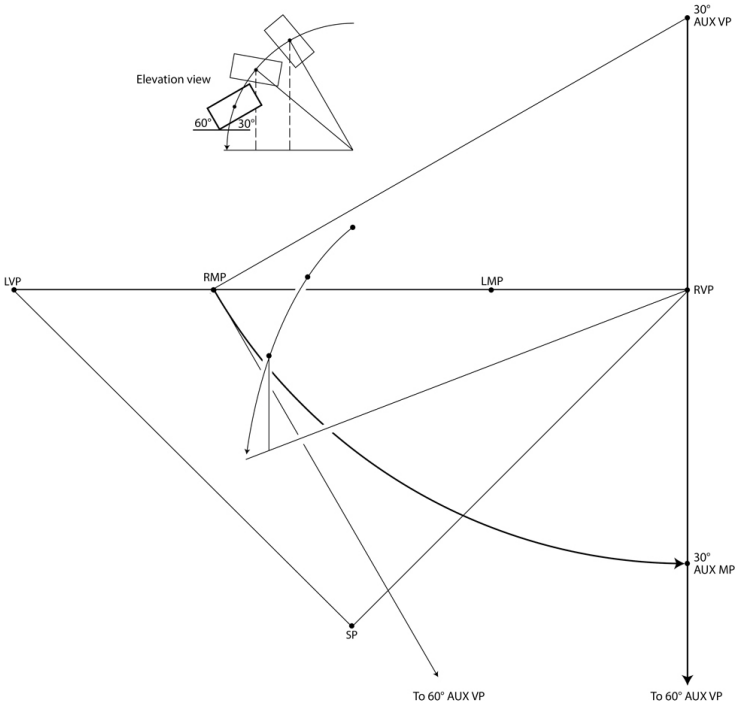

Figure 13.5 Placing the auxiliary measuring point on a vertical line keeps it nearby. **Return to text.**⏎

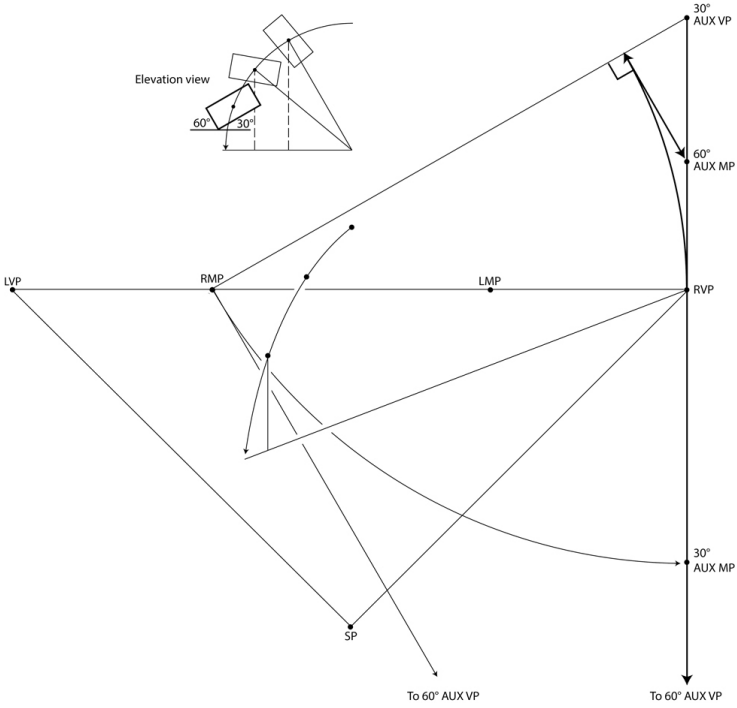

Figure 13.6 Establishing a vertical auxiliary measuring point when the auxiliary vanishing point is too far to reach. **Return to text.**⏎ 170.

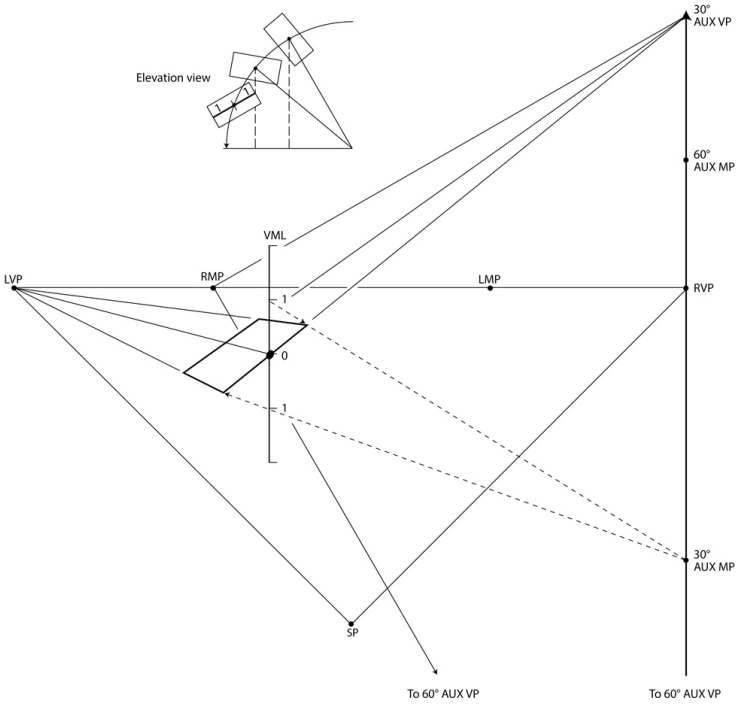

Figure 13.7 Measuring 2 units along the center plane. **Return to text.**⏎ 171.

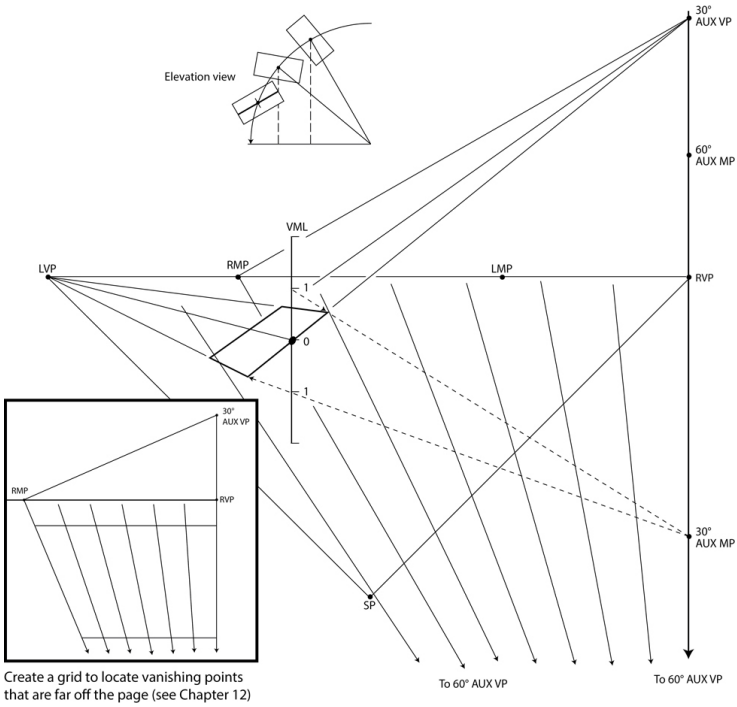

Figure 13.8 Create a grid to guide lines to the lower auxiliary vanishing point. See Chapter 12 for step-by-step instructions. **Return to text.**⏎

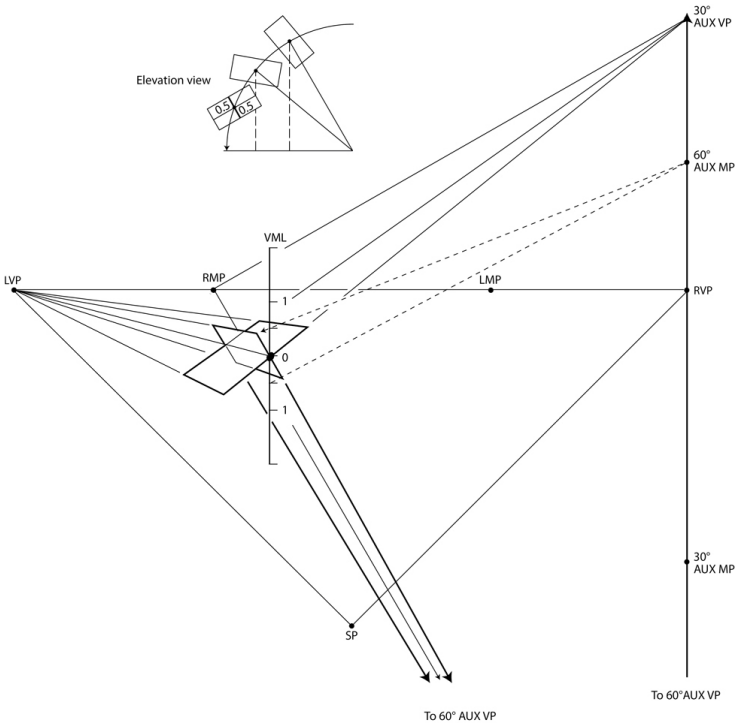

Figure 13.9 Measure 0.5 unit on each side of the zero point to establish the height. **Return to text.**⏎ 173.

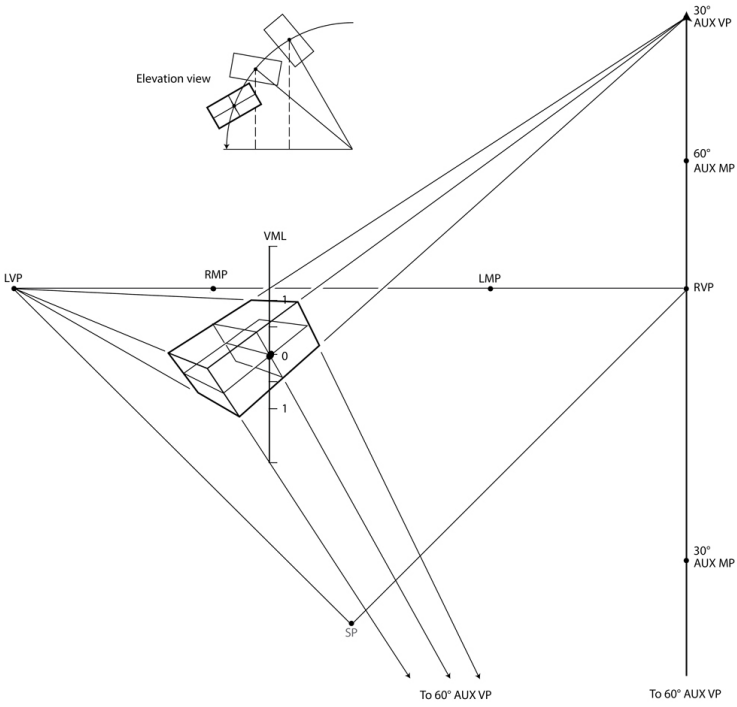

Figure 13.10 Connect to vanishing points to complete the box.
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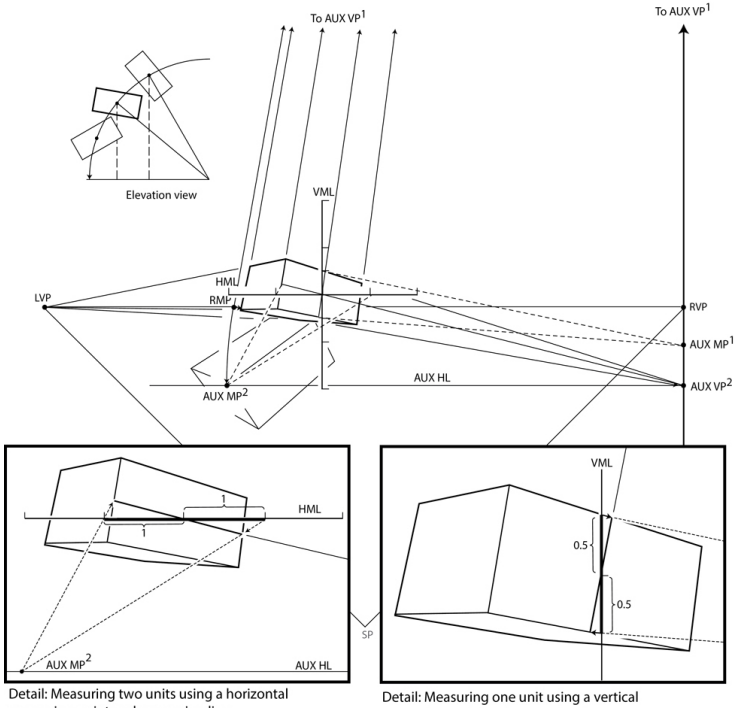


Figure 13.11 For the middle box, a horizontal measuring line was used for the depth (2 units), and a vertical measuring line was used for the height (1 unit). **Return to text.**⏎ 175.

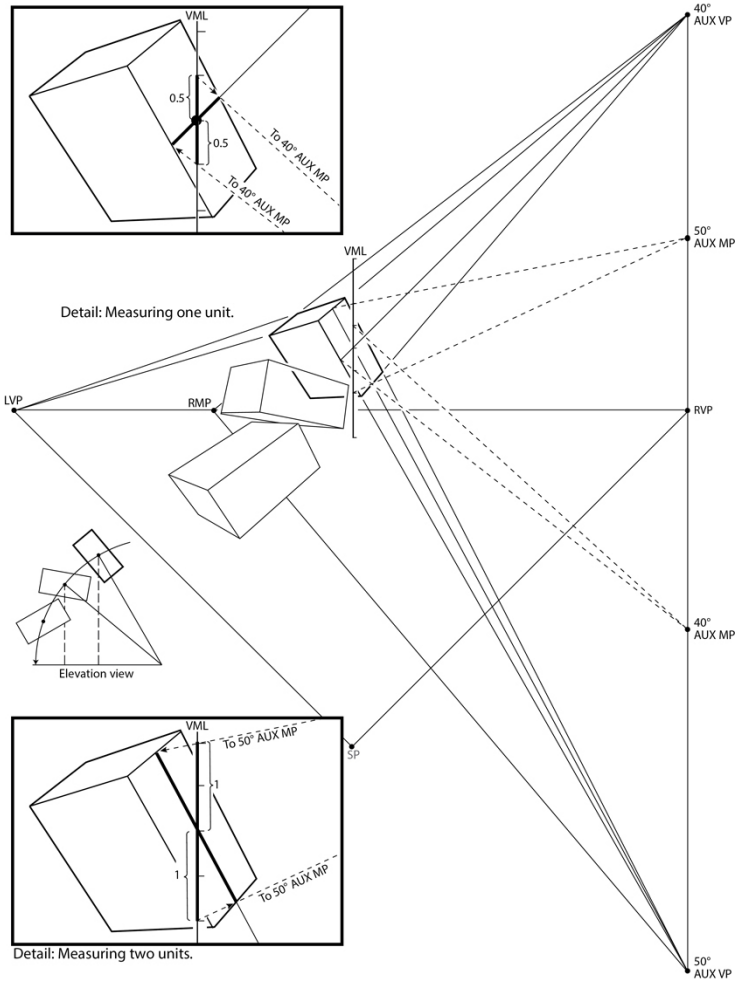


Figure 13.12 The completed boxes. **Return to text.**⏎

chapter 13
Falling and Rotating Forms

DOI: 10.4324/9781003488101-19

163. Auxiliary vanishing points can be daunting. Practice simple planes first, then advance to three-dimensional forms. When comfortable drawing inclines at various angles, then apply that knowledge to more elaborate scenes. Try incorporating several objects in a drawing, relating one object's movements to another.

Rotating Objects Example

Here is an example combining information from Chapter 8 and Chapter 10. In this example, a curved line will be drawn in perspective and a series of three objects rotating along that curve. They are spinning while they travel along a curved trajectory. This is more ambitious than previous examples, but there is nothing new in this series—the information has been covered before. Since much of this chapter is combining previous procedures, prior pages are referenced when appropriate.

The Axis Point

Assuming an object is balanced, and not heaver on one side, it will rotate along a central axis. To accurately measure the object, it must be measured from the axis point (the center of the box).

The Angles

The box is 1 unit high, 2 units long, and 2 units deep. Each sequence is separated by 20°. The first box rotates 40° counterclockwise, the second 80°, and the third 120°. It is helpful to draw an elevation view of complicated inclines, as it gives a visual of the true angles (Figure 13.1). This drawing may seem onerous, but drawing an angled box is no more difficult than drawing one angled line. Similarly, drawing three angled boxes is as easy as drawing one angled box. Draw this series one box at a time, and draw each box one line at a time.

The Arc

Begin by drawing the arc. This is the path the boxes will follow. The center of each box is aligned with this curve (Figure 13.2). Refer to Chapter 8, Figure 8.28.

Auxiliary Vanishing Points

After the arc and the center of all three boxes are plotted, the next task is to locate the auxiliary vanishing points. Each box is at a different angle, so each box will need a different pair of auxiliary vanishing points (this is best done on separate overlays). When drawing inclines, true angles are found at the measuring point. It is helpful to think of the measuring point as an elevation view of the incline. Place the angles given in the following instructions on the measuring point. Then project those angles to create auxiliary vanishing points (Figure 13.3). As often happens, some of the auxiliary vanishing points may be far off the page. This can be dealt with by drawing a grid as discussed in Chapter 12, Figure 12.5.

Bottom Box

Start with the box closest to the viewer—the bottom box. This box is tilted at a 60/30° angle to the ground plane (Figure 13.3, top). From the measuring point, project a 30° angle to find the upper auxiliary vanishing point. Then, project a 60° angle to find the lower auxiliary vanishing point (Figure 13.4).

Auxiliary Measuring Points

Next, establish the auxiliary measuring points (Figure 13.5). To save space, use vertical measuring points. Refer to Chapter 11, Figure 11.2.

169. The lower auxiliary vanishing point is off the page (Figure 13.6). Use the technique outlined in Chapter 12, Figure 12.4, to compensate for this problem.

Measuring Depth

The depth is 2 units. Measure from the center of the box, 1 unit on each side of the axis point. If using a vertical measuring point, make sure the measuring line is also vertical and positioned at the axis point of the box, touching the line being measured (Figure 13.7).

Measuring Height

The height is 1 unit. Since the lower auxiliary vanishing point is off the page, use the technique outlined in Figure 12.3 to create a grid. The grid assists in guiding the direction of the lines. Make the grid as tight as needed (Figure 13.8).

172. Measure 0.5 unit on each side of the axis point (Figure 13.9).

Complete the Box

Connect corners to vanishing points to complete the box (Figure 13.10).

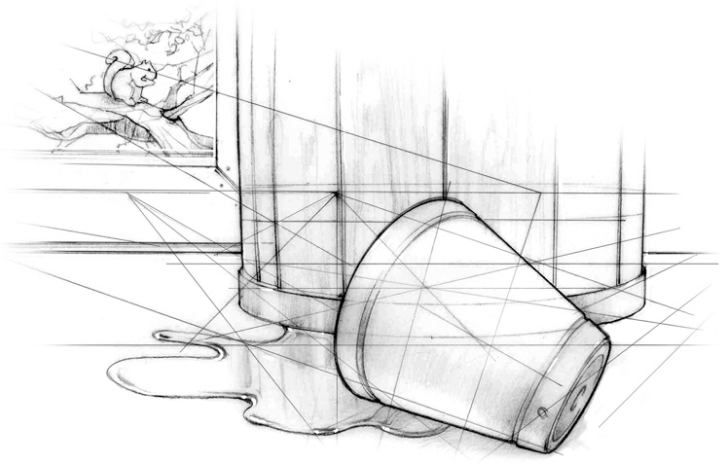
Middle Box

The middle box is drawn in the same fashion as the first. The steps are the same. However, the measuring line must be moved back in space (in perspective). The measuring line must touch the center (axis point) of the box being measured.

In this case, to measure the depth, place the auxiliary measuring point on a horizontal line. It is closer and more convenient than placing it on a vertical line (Figure 13.11). It is useful to have options. To complete this box, follow the same steps used to draw the previous box (Figure 13.10).

Top Box

When drawing the top box, repeat the process used to draw the bottom box. Use vanishing points and measuring points that correspond to the 50° and 40° angles (Figure 13.12).



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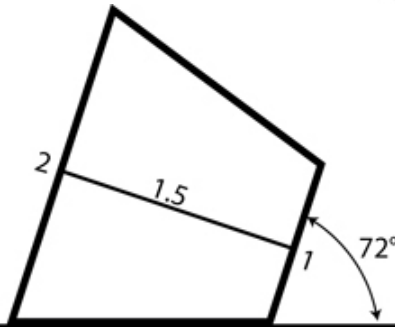


Figure 14.1 An elevation view is a helpful tool to display complicated angles. **Return to text.**⏎ 178.

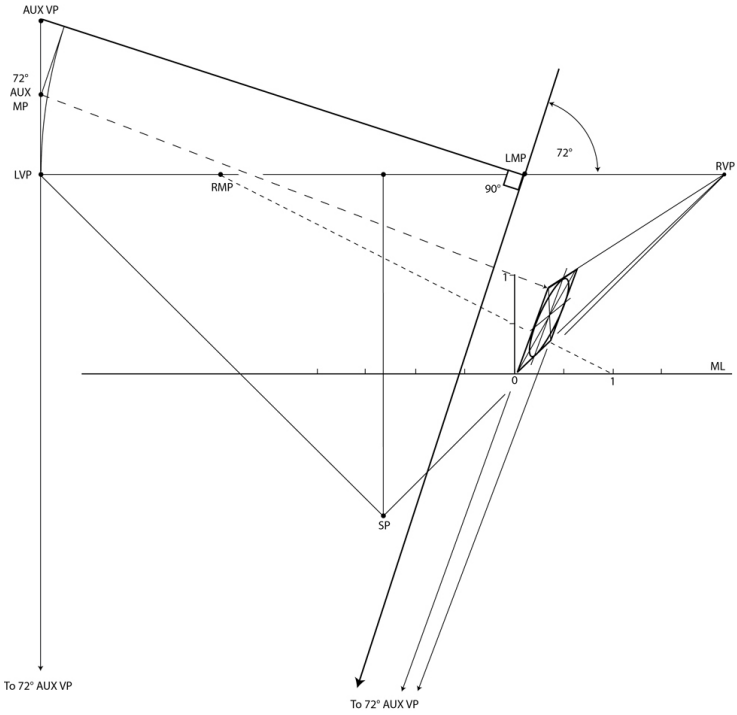


Figure 14.2 Using the left measuring point, create a 72° incline. **Return to text.**⏎ 179.

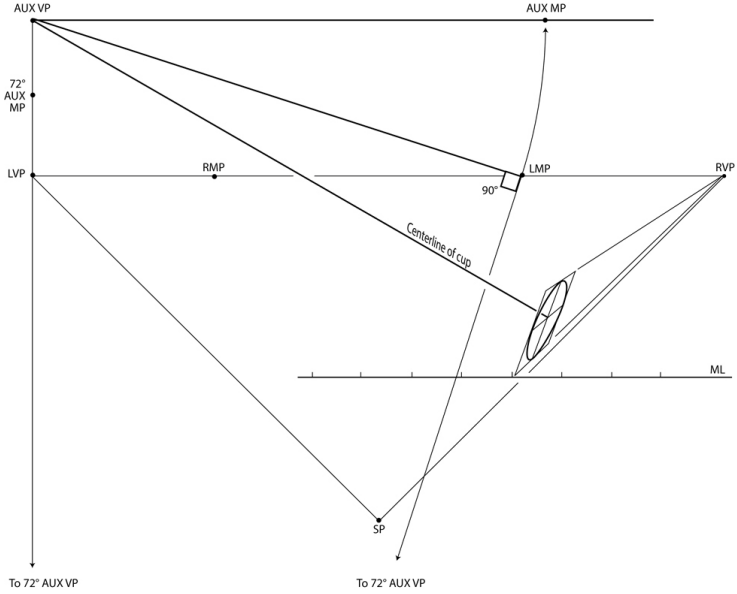


Figure 14.3 Draw a centerline 90° from the base. **Return to text.**⏎

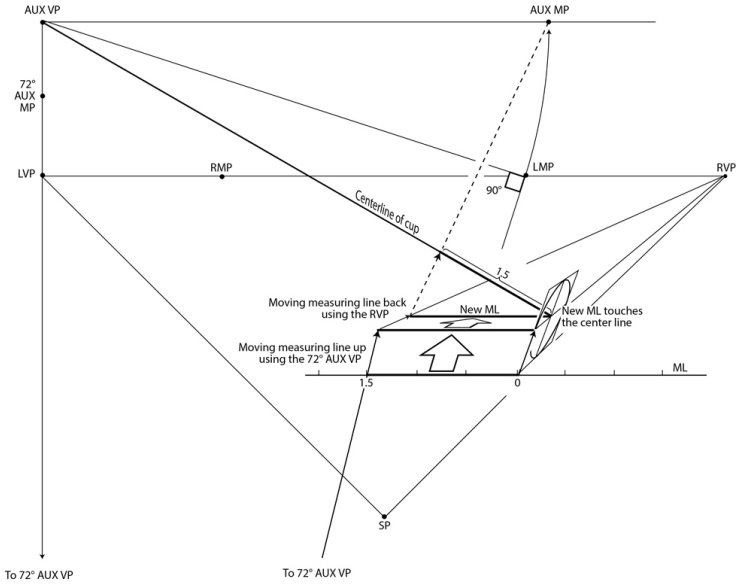
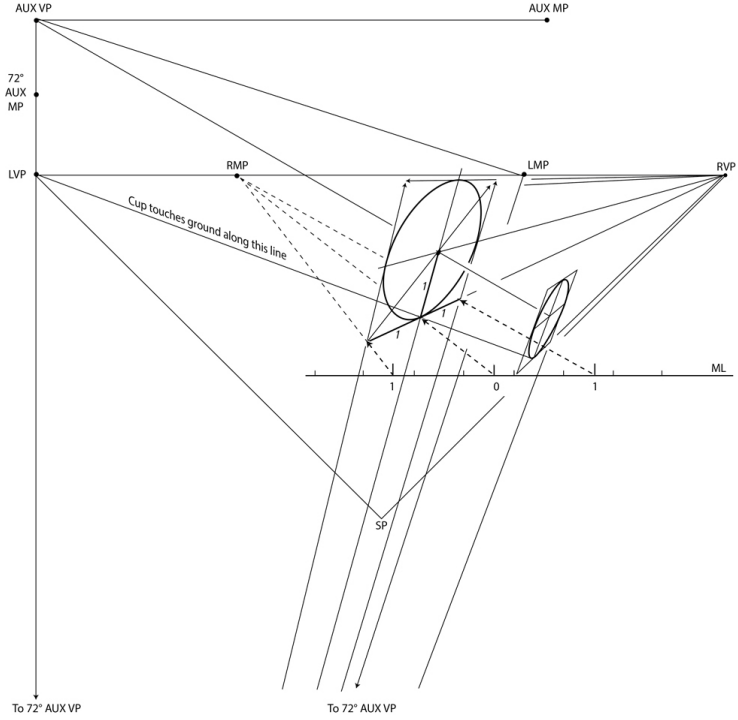


Figure 14.4 Measure the cup's height (1.5 units) by relocating the measuring line. It must touch the line being measured. **Return to text.**⏎ 181.



Figure

14.5 There are several steps in this illustration. First, find the point where the top of the cup touches the ground. Measure 1 unit on each side of this point. Project a diagonal line from the bottom left corner, through the center point, until it intersects the top right corner of the square. Draw an ellipse. **Return to text.**⏎ 182.

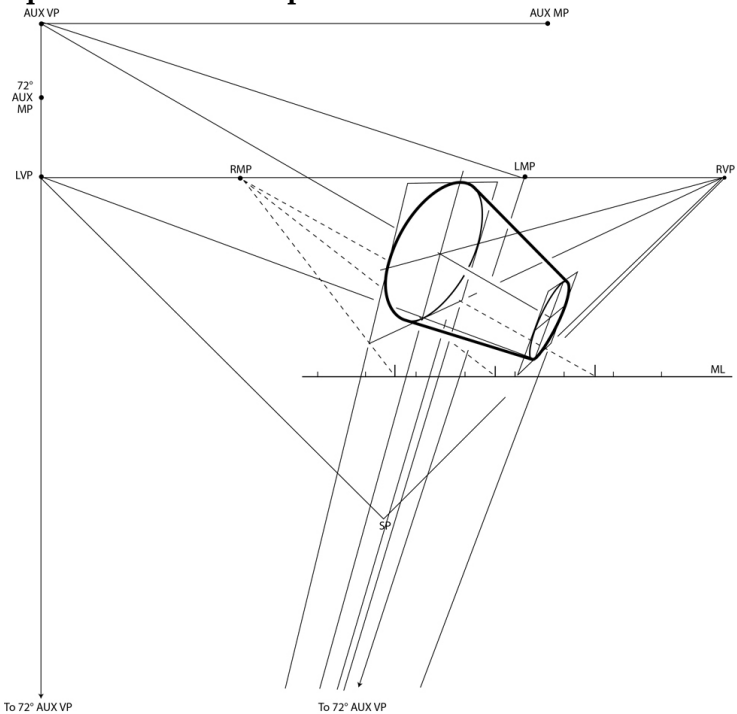


Figure 14.6 Connect the ellipses to complete the cup. **Return to text.**⏎

chapter 14
Tilted Tapered Forms

DOI: 10.4324/9781003488101-20

177. A tapered cup is simple when upright (Figure 8.18). When

it tips over, it is not so simple. A tapered cup on its side creates some challenging angles, as well as an opportunity to practice ellipses.

The Cup

As an example, use the cup drawn in Figure 8.18. The cup is 1.5 units tall. The diameter of its base is 1 unit, and the diameter of its top is 2 units. It may be worth reviewing Chapter 9, as this chapter builds on that information. Keep in mind there are several ways to solve this problem. Understanding the geometry of perspective reveals a myriad of solutions to a single problem.

Elevation View

As pointed out previously, it is prudent to draw an elevation view of complicated inclines. An elevation view gives insight to the angles that need to be drawn. The cup, when on its side, creates a 72° angle (rounded off) from the ground plane to its base (Figure 14.1).

Base

The base's diameter is 1 unit. First draw a 1-unit square, tilted 72°. Then draw an ellipse inside the tilted square (Figure 14.2). Review Chapter 8 for methods to draw an ellipse.

Height

The cup is 1.5 units tall. The centerline of the cup is 90° from the base. To draw the centerline, first plot an auxiliary vanishing point 90° from the vanishing point of the base (Figure 14.3). Use this auxiliary vanishing point to draw the centerline of the cup.

To measure the height, establish an auxiliary measuring point and a measuring line parallel to the line the measuring point is on.

180. The measuring line must be moved so that it touches the centerline. There are many paths to do this. This example uses

the 72° auxiliary vanishing point to project the measuring line up. Then, the right vanishing point is used to project the measuring line backward until it touches the centerline (Figure 14.4).

Top

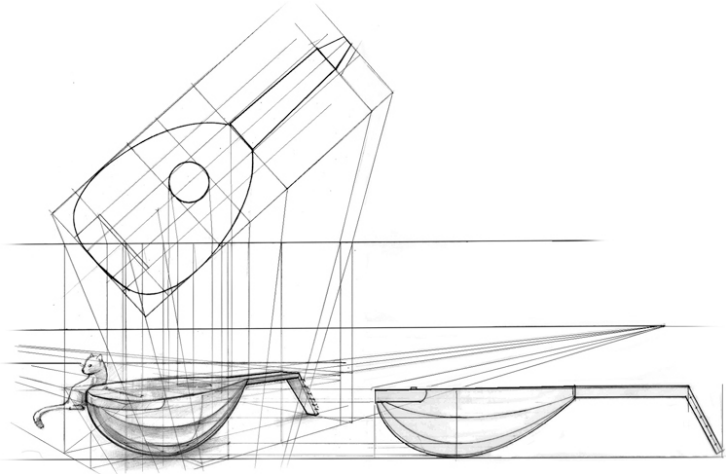
The 1.5-unit centerline establishes the middle of the cup's top. The cup's top has a radius of 1 unit. Measure out from the center, 1 unit on each side, to create a 2-unit square; then draw an ellipse (Figure 14.5).

Finish

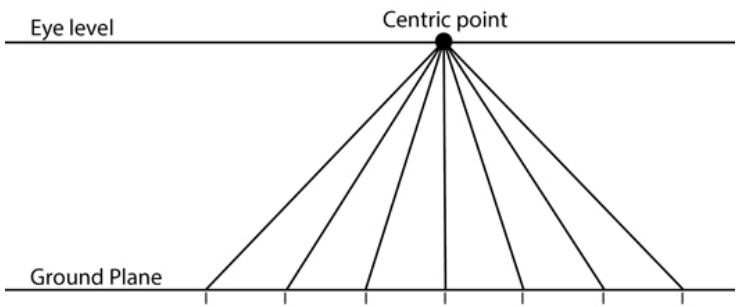
Connect the ends of the two ellipses to finish the cup (Figure 14.6).

183. 184.

part seven
Plan/Elevation View Perspective

185. 

Elevation from the front



186. Evenly divided spaces

Figure 15.1 Evenly spaced horizontal lines receding in space. **Return to text.**⏎ 187.

Elevation from the side

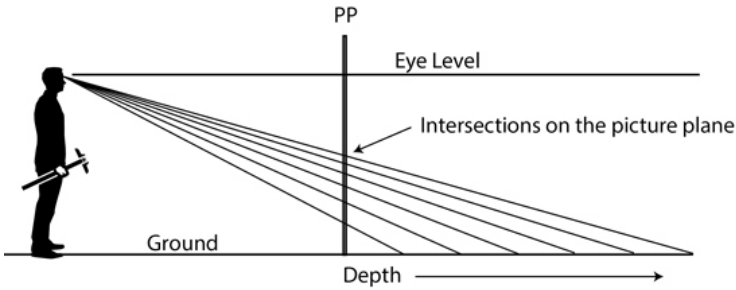
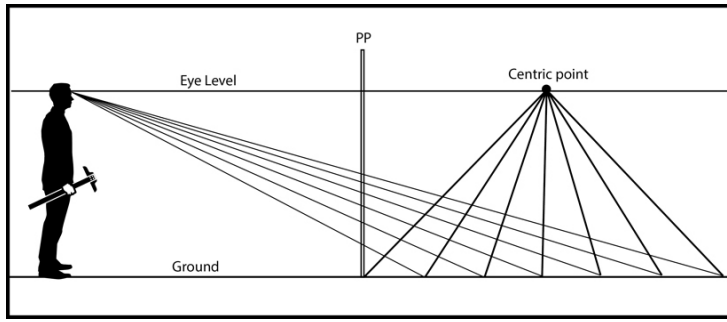


Figure 15.2 Using an elevation view to define depth. **Return to**



text.⏎

Figure 15.3 Combining the two elevation views into one diagram. Return to text.⏎

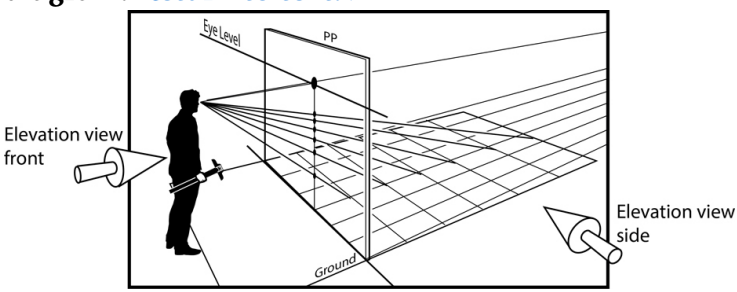


Figure 15.4 A three-dimensional view of Figure 15.3. Return to text.⏎ 188.

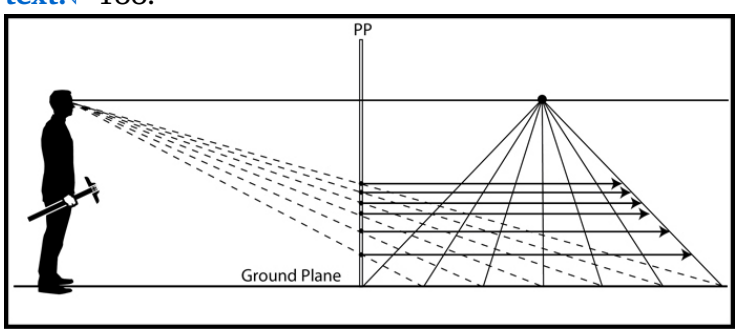


Figure 15.5 A one-point perspective grid using Alberti's 1435 diagram. Return to text.⏎ 189.

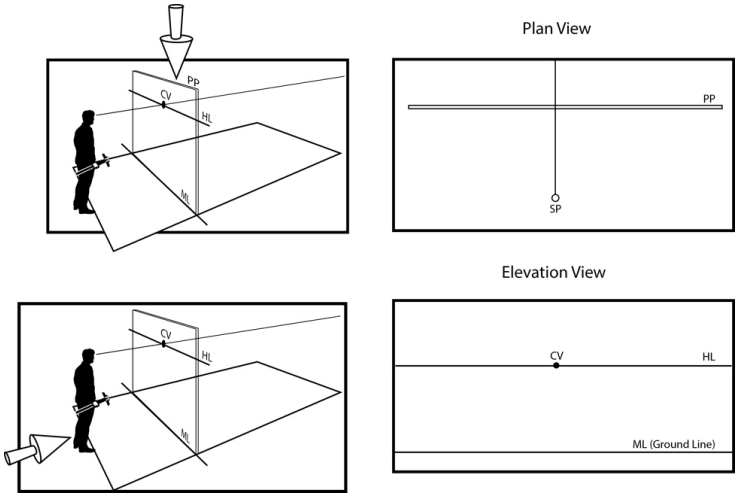


Figure 15.6 Plan and elevation views. On the left is a three-dimensional view. On the right is how this view is represented on paper. **Return to text.**⏎ 190.

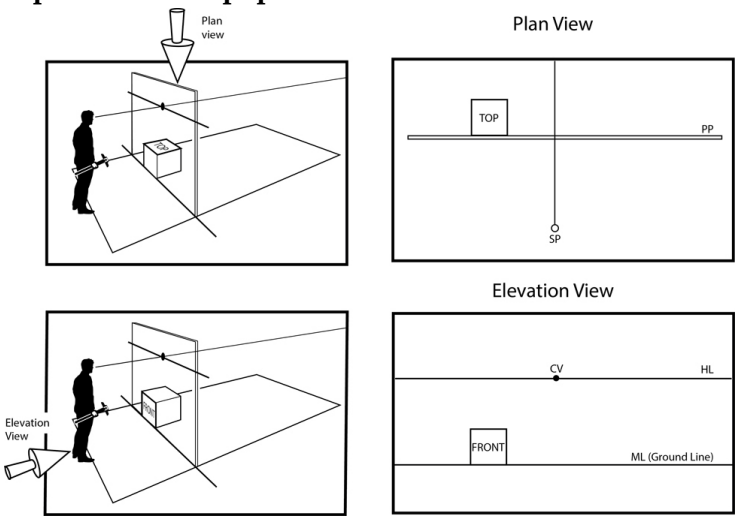


Figure 15.7 A cube in plan and elevation view, in three- and two-dimensional views. **Return to text.**⏎ 191.

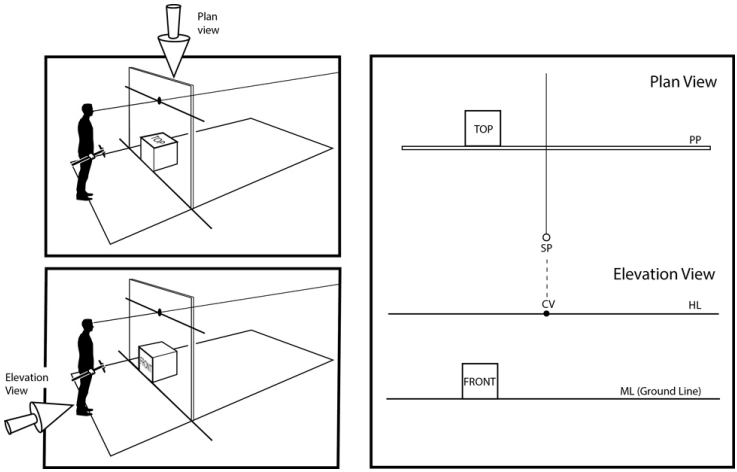


Figure 15.8 The plan view is placed above the elevation view. The station point and center of vision must be aligned. **Return to text.**⏎ 192.

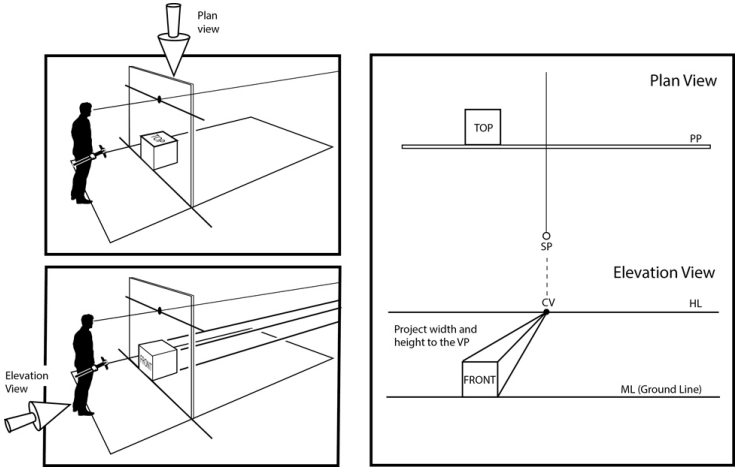


Figure 15.9 Connect foreshortened lines to the center of vision. **Return to text.**⏎ 193.

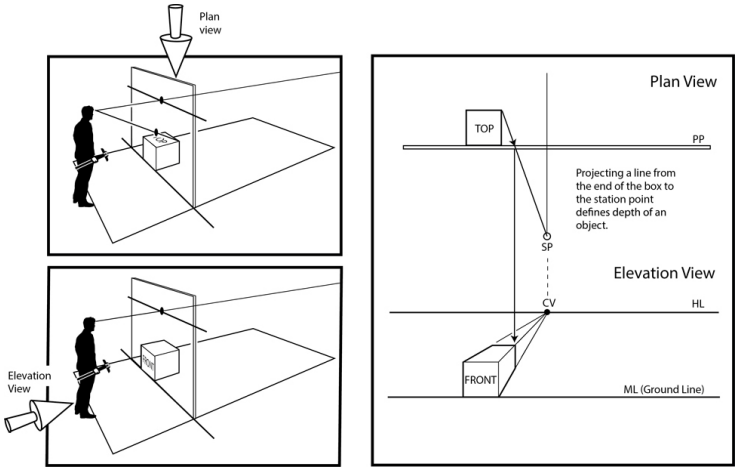


Figure 15.10 Measure depth by plotting its intersection on the picture plane. **Return to text.**⏎ 194.

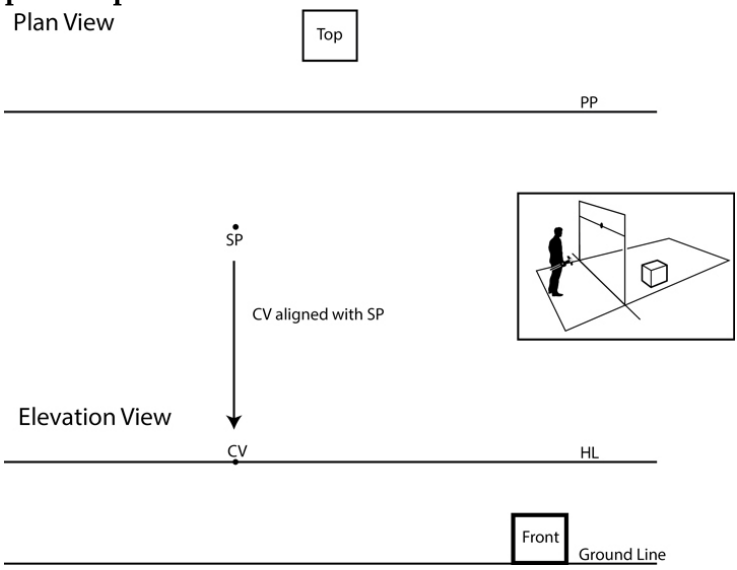


Figure 15.11 Plan and elevation diagram showing a cube in one-point perspective. In the elevation view, the cube is placed to the right of the image area. **Return to text.**⏎ 195.

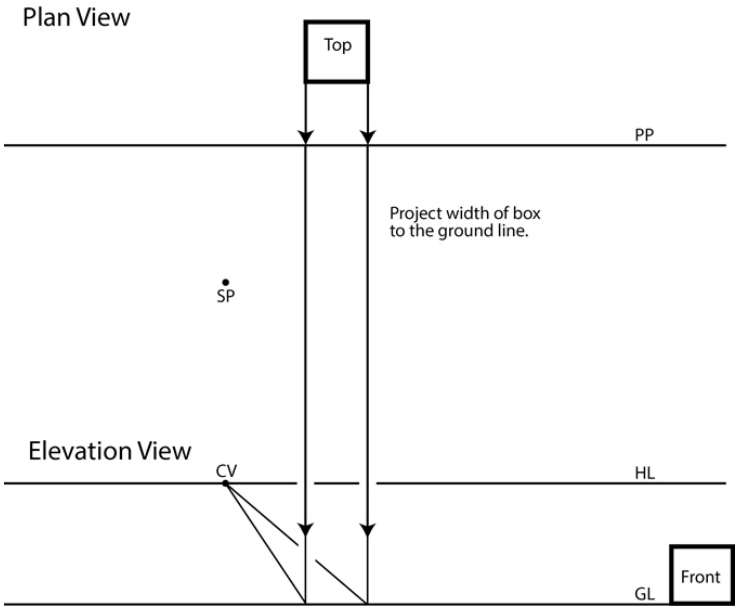
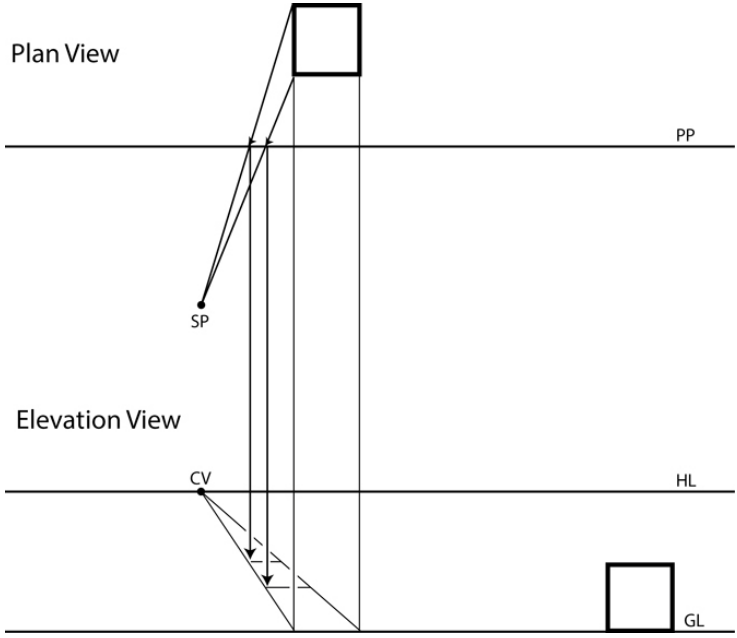


Figure 15.12 Plot the width of the cube by projecting it to the picture plane and then to the ground line. **Return to text.**⏎



196.

Figure 15.13 Use the station point to plot the depth of the cube. **Return to text.**⏎ 197.

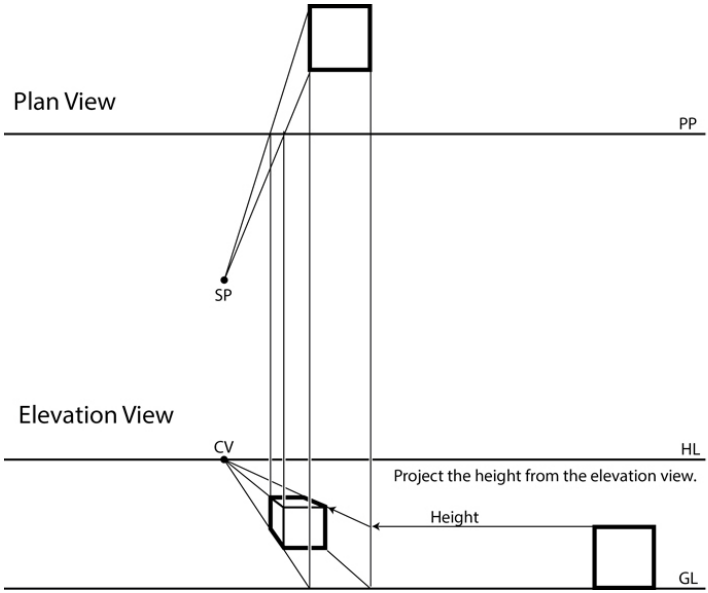


Figure 15.14 Plot the height of the cube using the elevation view. **Return to text.**⏎ 198.

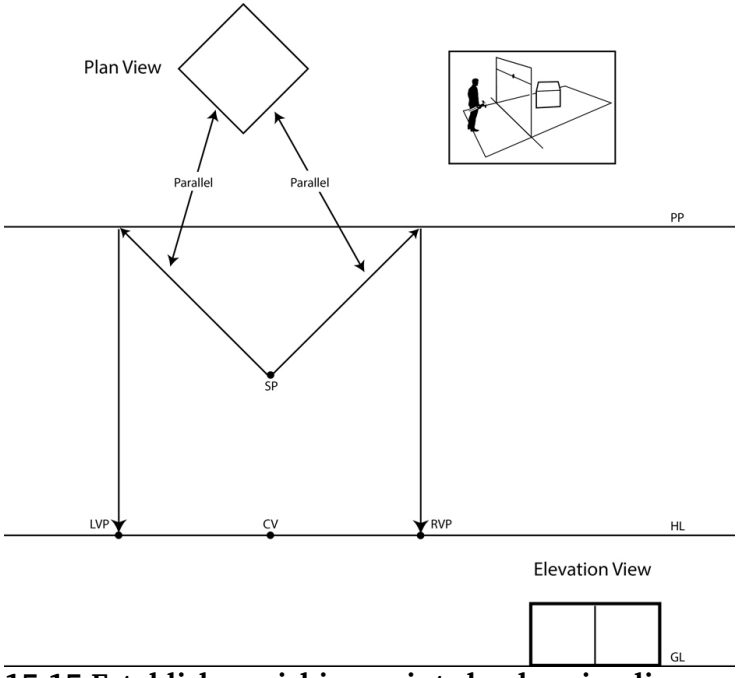


Figure 15.15 Establish vanishing points by drawing lines parallel to the object in the plan view. **Return to text.**⏎ 199.

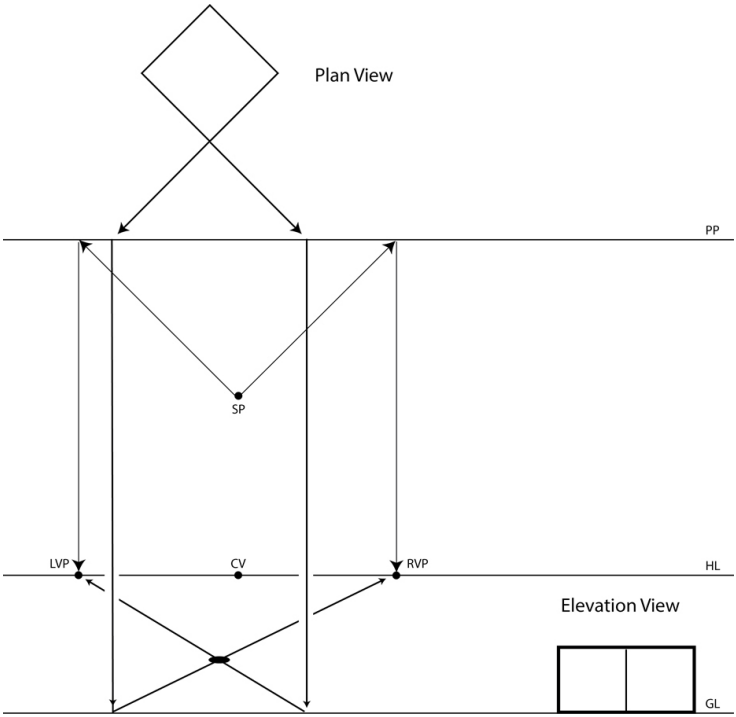


Figure 15.16 The intersection of the two lines defines the location of the box's front corner. **Return to text.**⏎ 200.

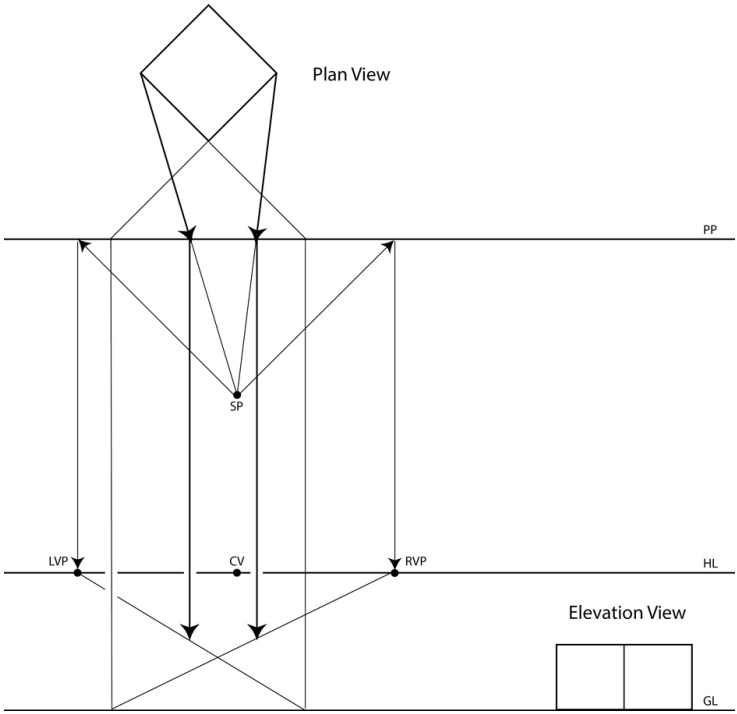


Figure 15.17 To determine depth, draw a line to the station point intersecting the picture plane, then drop these lines to the box. **Return to text.**⏎ 201.

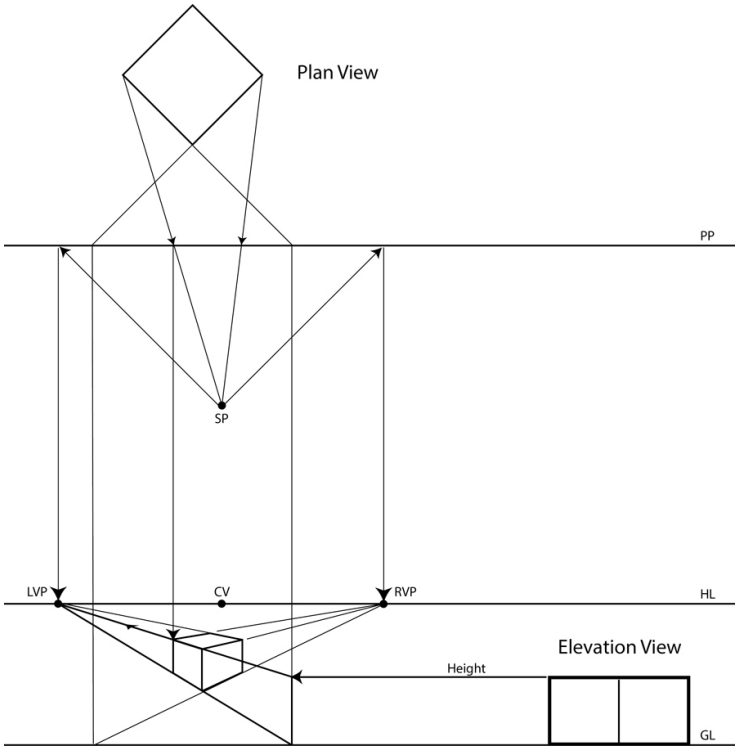


Figure 15.18 Use the elevation view to establish the height. Connect lines to vanishing points to finish the box. **Return to text.**⏎ 202.

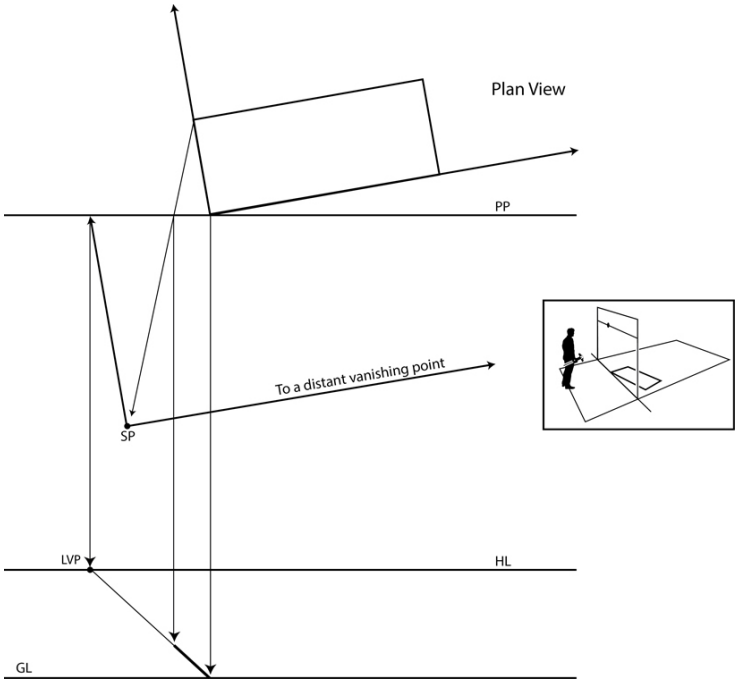


Figure 15.19 The right vanishing point is too far away to comfortably plot. **Return to text.**⏎

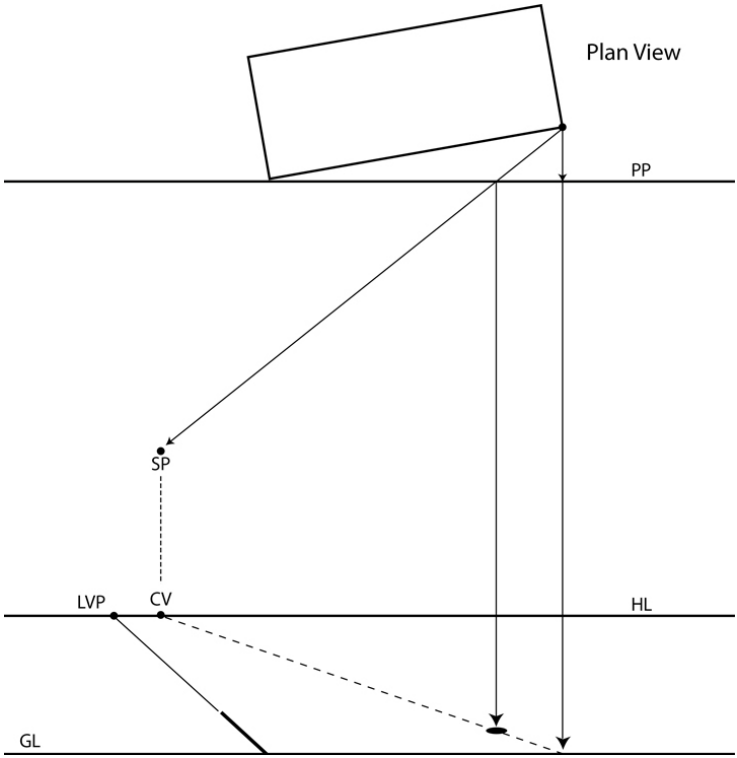


Figure 15.20 Use one-point perspective techniques to draw the right front corner of the box. Any point in space can be found using one-point perspective. **Return to text.**⏎ 203.

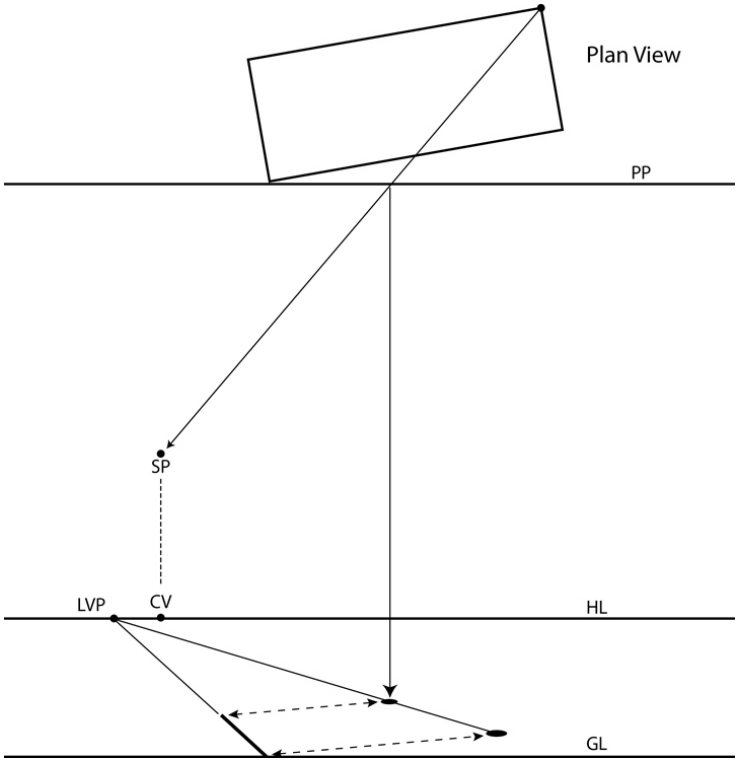


Figure 15.21 Use the same technique to draw the back corner of the box then connect the dots. **Return to text.**⏎ 204.

chapter 15
Plan/Elevation View Perspective

DOI: 10.4324/9781003488101-22

The Birth of Perspective

In 1413 Fillipo Brunelleschi (1377–1446) painted the first image to fully adhere to the rules of perspective. Leon Battista Alberti (1404–1472) was the first to diagram this approach, publishing his book *On Painting* in 1435 and introducing

perspective to the world. This nascent method of perspective did not use measuring lines and measuring points. It approached the problem of depicting depth not by drawing isosceles triangles but by projecting the object being drawn to the picture plane using the visual pyramid (lines drawn to the viewer's eye).

Quattrocento artists had a solid understanding of how the picture plane worked—how lines, projected from the object to the viewer's eye, would create an accurate image of reality at the intersection of the picture plane. They cleverly used this knowledge to construct a diagram that took advantage of this insight. This diagram gave artists something they never had: a way to draw with accuracy.

The measurement system that has been used thus far is not the only way to draw in perspective; there is an alternative to drawing isosceles triangles. It utilizes techniques that can be traced directly to Leon Battista Alberti. The plan/elevation view diagram used today is arranged differently, but the procedure has not changed in 600 years. As a direct descendant of the first perspective diagram, plan/elevation view perspective presents an opportunity to discuss some history and explain perspective's evolution. Exploring this 600-year-old procedure segues seamlessly into the modern measurement system. So this chapter begins by outlining how perspective originated.

Plan/elevation view perspective is a direct descendent of this 600-year-old method. Exploring Alberti's diagram may give the plan/elevation perspective method some context.

Alberti's Measuring Methods

Width

Once artists discovered that parallel lines connect to a vanishing point, measuring horizontal dimensions was relatively easy. Horizontal lines are not foreshortened; they are parallel to the picture plane. They can be measured with a ruler (Figure 15.1). Measuring depth is trickier.

Depth

Depth is foreshortened. It can't be measured directly with a ruler. In the previous chapters, an isosceles triangle was used to measure foreshortened lines. The Quattrocento artists approached it differently—they used an elevation view to plot depth. Drawing the intersection of the visual pyramid on the picture plane projected the foreshortened line to a flat surface (Figure 15.2).

One-Point Diagram

So, now width can be defined using an elevation view from the front, and depth defined using an elevation view from the side (Figure 15.1 and Figure 15.2). Combining the two views gives the foundation of Alberti's 600-year-old perspective diagram (Figure 15.3). A perspective view of this diagram may better explain the relationships (Figure 15.4). Alberti's diagram creates a one-point perspective grid.

One-Point Grid

The intersections at the picture plane define depth. Project the intersections horizontally to create a grid (Figure 15.5).

Plan/Elevation View Perspective

The Diagram

The plan/elevation view diagram is similar to Alberti's first perspective diagram, the main difference being that instead of using a side elevation view to plot depth, a plan view is used to accomplish the same purpose.

A plan view shows the station point and its distance from the picture plane. The elevation view shows the horizon line, the center of vision, and the ground line (because there is no measuring, the measuring line is now called a ground line) (Figure 15.6).

Station Point

The distance from the station point to the picture plane determines how large the cone of vision will be. The farther away the viewer is from the picture plane, the larger the cone of vision (the station point is often placed below the elevation view to allow for a large image area).

Ground Line

What was called the measuring line is now called a ground line. The ground line is located at the picture plane and determines the viewer's eye level. The closer the ground line is to the horizon line, the lower the eye level.

The Object

The plan view displays the top of the object (this gives the width and depth); the elevation view displays the front of the object (this gives the height) (Figure 15.7).

The Drawing

With the elevation and a plan view in place, it is time to create the drawing. Alberti superimposed the two elevation diagrams, putting one on top of the other. The modern approach is a little different: the plan view is separated from the elevation view. The plan view is traditionally placed at the top of the paper, with the elevation view placed below. It does not matter how far apart the diagrams are, but the center of vision in the elevation view must be aligned with the station point below (Figure 15.8).

The box in this example is in one-point perspective. This is shown by its position relative to the picture plane. The box in the plan view and the box in the elevation view are the same object; therefore, the plan and elevation view must be drawn to the same scale. If there are several objects to draw, the size and positioning of each object must also be to scale.

Elevation View

Foreshortened lines in one-point perspective connect to the center of vision (Figure 15.9).

Plan View

To measure the depth, draw a line from the back of the box to the station point. Where this line intersects the picture plane, project downward to the ground plane, defining the back of the box (Figure 15.10).

This is how to draw a box using the plan and elevation method. No measuring points or measuring line were used, and all dimensions were projected to the picture plane. Now try to do another one-point view with a different shape in a different position.

Objects Not Touching the Picture Plane

When a one-point box touches the picture plane, height and width are actual size. In this next example, the box is behind the picture plane. Begin by drawing the diagram. Place the elevation view of the box to the right of the image area. It is usually more convenient—especially when drawing several objects—to place the elevation view on the right side of the paper. This keeps the diagram less cluttered [Figure 15.11, bottom]).

Width

Project the width to the picture plane then drop that distance to the ground line. Any point not touching the picture plane must first be projected to the picture plane before being drawn to the ground (Figure 15.12).

Depth

Determine depth by drawing a line from the object's corners to the station point. Plot the intersection at the picture plane, then

project the intersection to the ground (Figure 15.13).

Height

The elevation view displays the true height at the picture plane. This dimension must be projected back in space if the object being drawn does not touch the picture plane (Figure 15.14).

Two-Point Plan/Elevation

Finding Vanishing Points

Objects in two-point perspective are angled to the picture plane. These angles can be seen in the plan view. The placement of the right and left vanishing points must reflect the angle of the object being drawn. Since angles at the station point are true angles, the lines projected from the station point must be parallel to the angles of the object. Where the lines intersect the picture plane, drop them to the horizon, creating a left and right vanishing point (Figure 15.15).

The Drawing

As in one-point perspective, lines that do not touch the picture plane must be projected to the picture plane. Once the line touches the picture plane, it is then dropped down to the ground line. From the ground line, connect the lines to their respective vanishing points. The intersection of the two angles indicates the front corner of the box (Figure 15.16).

Depth

In the plan view, draw a line from the left and the right corner of the box to the station point. Use the intersection at the picture plane to define the depth of the box (Figure 15.17).

Height

Height is determined from the elevation view. Project the

height across the picture plane, then backward using a vanishing or reference point (Figure 15.18).

Connect lines to vanishing points to finish the box.

The Problem of Distant Vanishing Points

If a right or left vanishing point is far off the page (Figure 15.19), the two-point object can be drawn using one-point techniques. Any single point may be found using one-point perspective. Once the distant corner is found, connect the dots (Figure 15.20–21).

205. 206.

part eight
Three-Point

207.

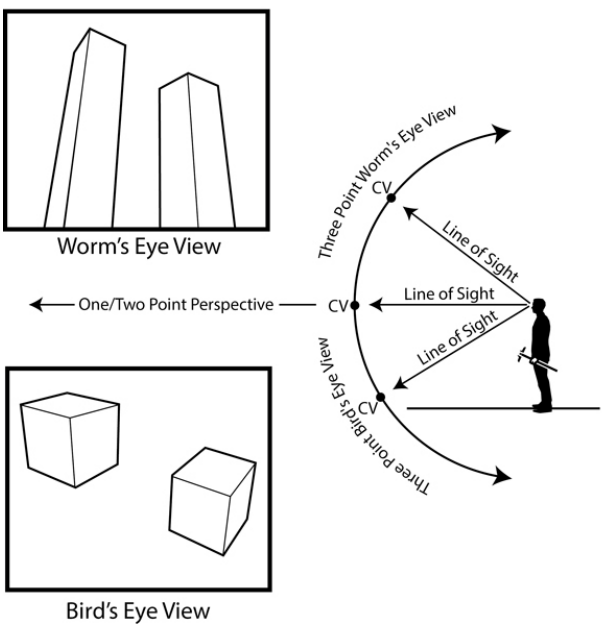


Figure 16.1 The viewer is looking up or down in three-point perspective. **Return to text.**⏎ 209.

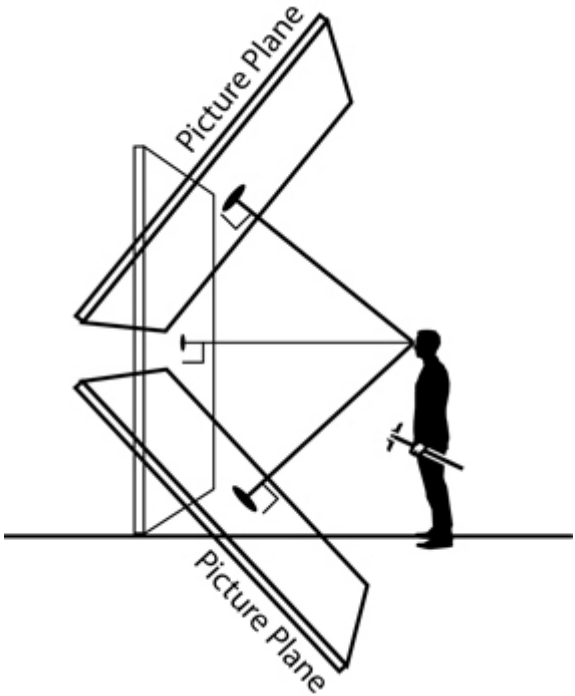


Figure 16.2 The picture plane is at a right angle to the line of sight. **Return to text.**⏎

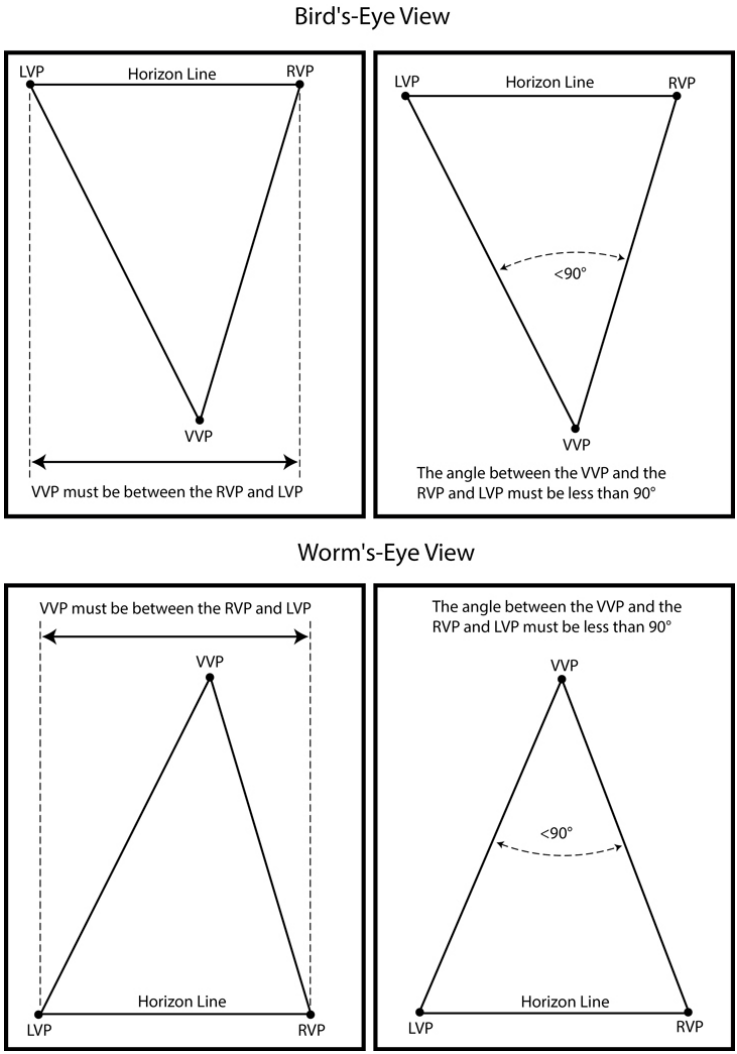


Figure 16.3 Follow these guidelines for the proper placement of vanishing points. **Return to text.** 210. 211.

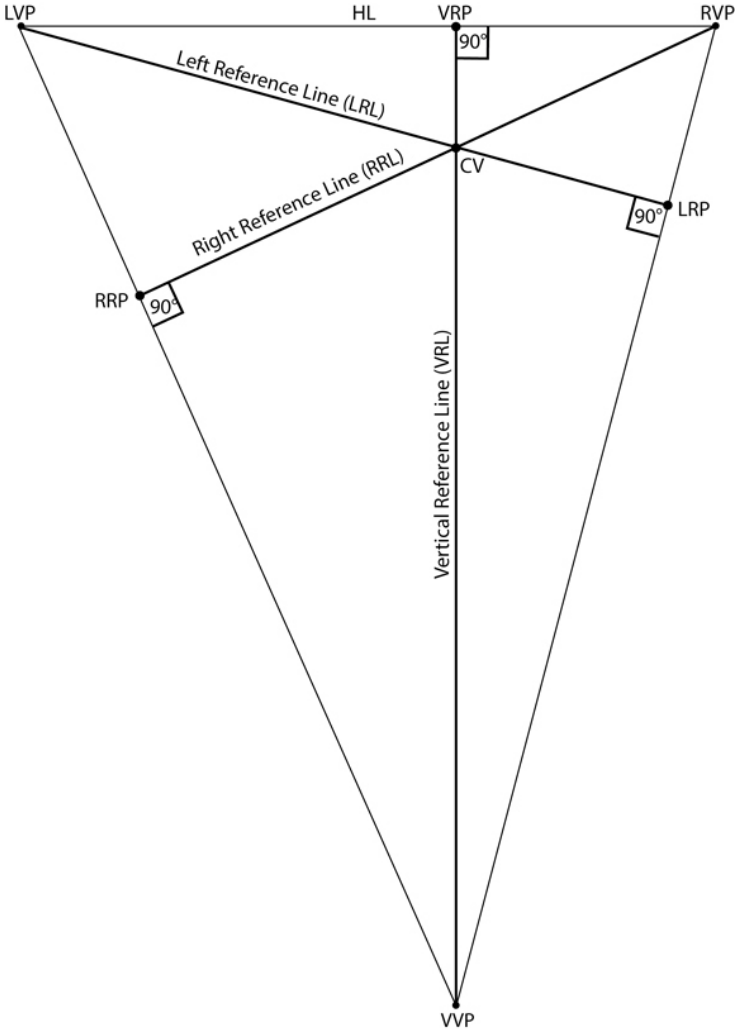


Figure 16.4 The location of the center of vision is at the intersection of the three reference lines. Return to text.⏎

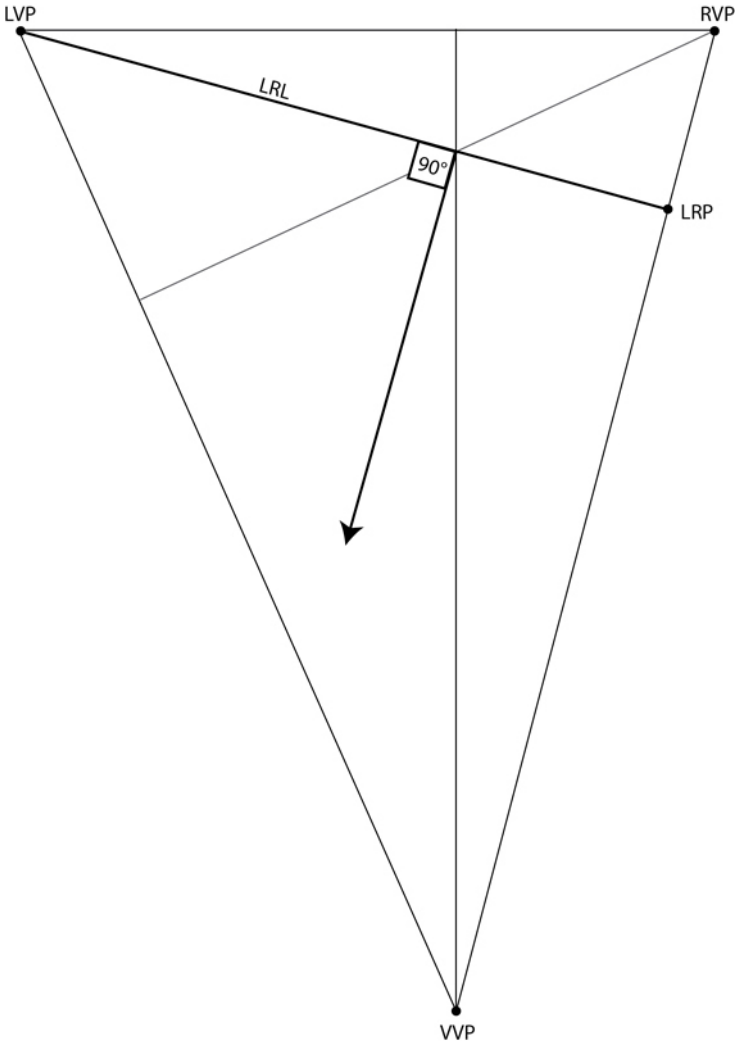


Figure 16.5 From the center of vision, project a right angle from the left reference line. **Return to text.**⏎

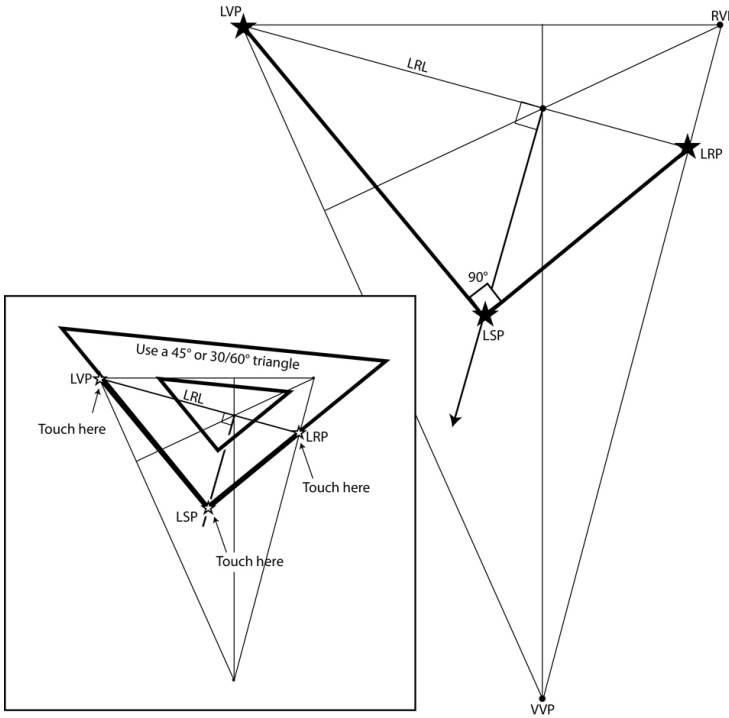


Figure 16.6 Use a triangle to locate the left station point. **Return to text.**⏎ 214.

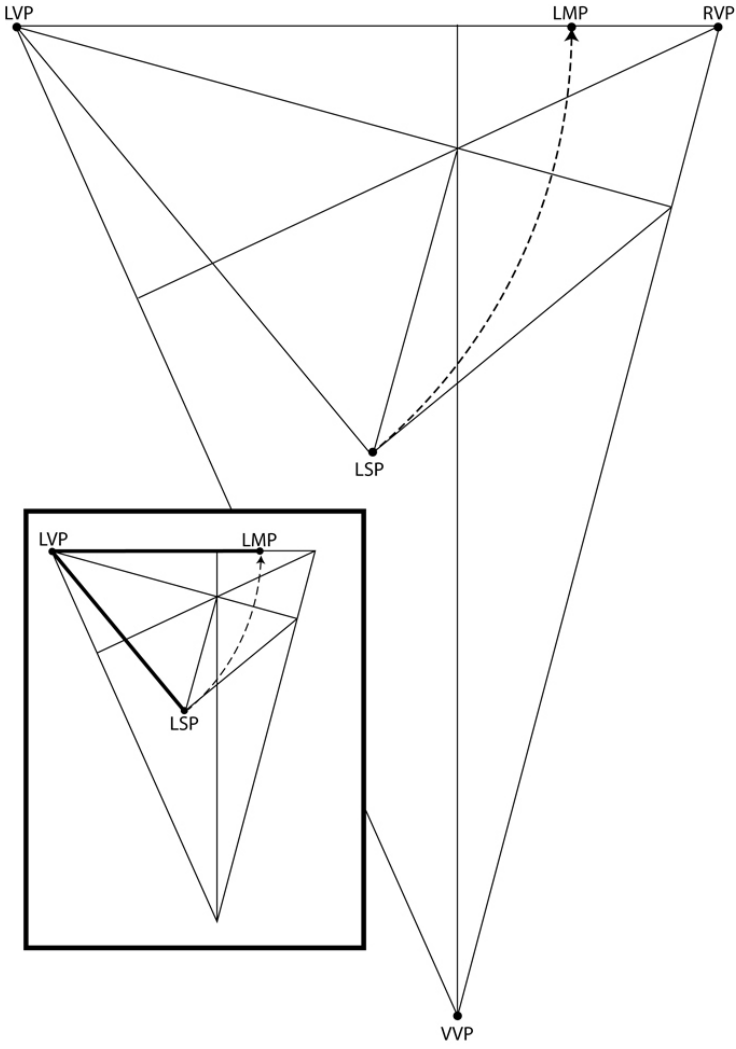


Figure 16.7 Measure the distance from the left vanishing point to the left station point. Transfer that distance to the horizon line. **Return to text.**⏎ 215.

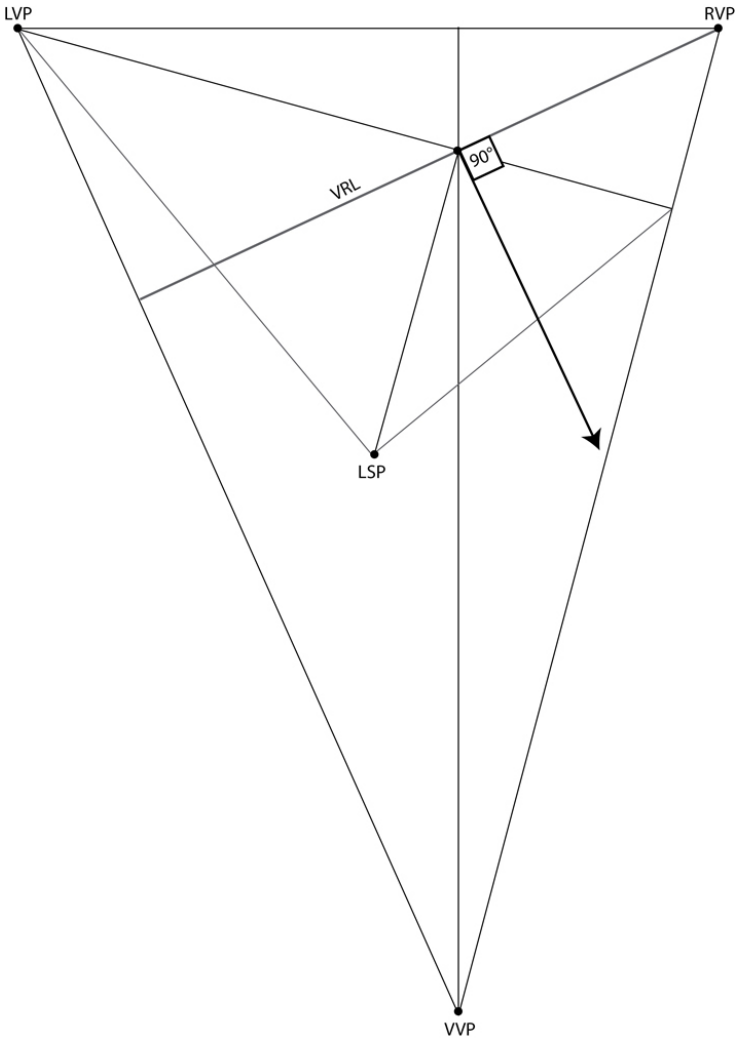


Figure 16.8 At the center of vision, extend a line 90° from the right reference line. **Return to text.**⏎

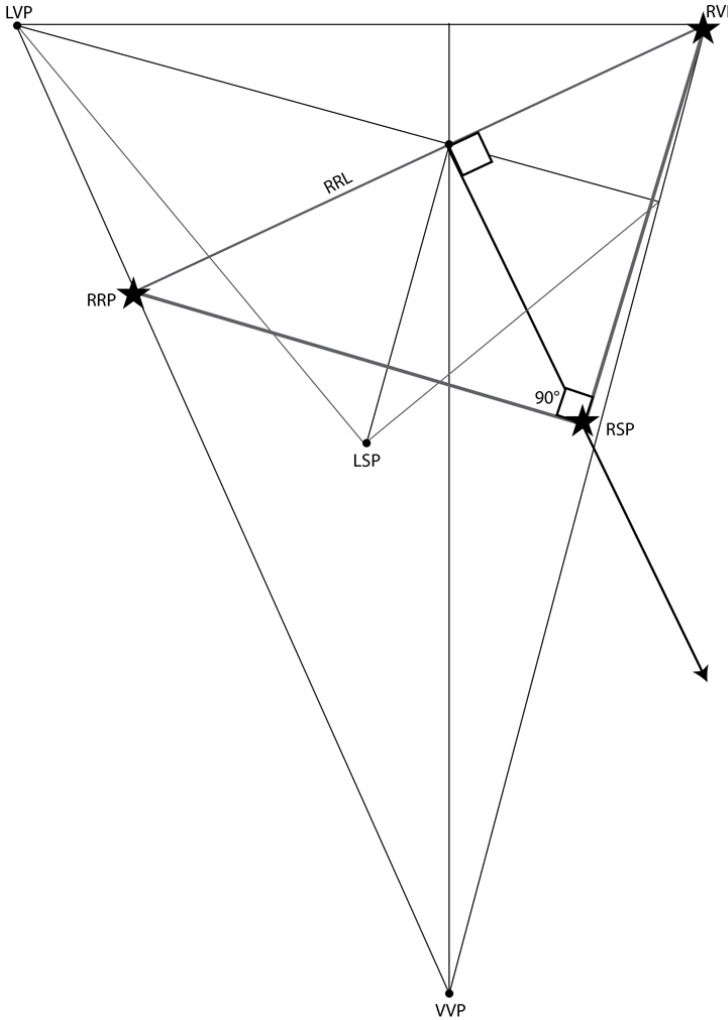


Figure 16.9 Triangulate the right vanishing point, the right reference point, and the right station point. **Return to text.**⏎ 216.

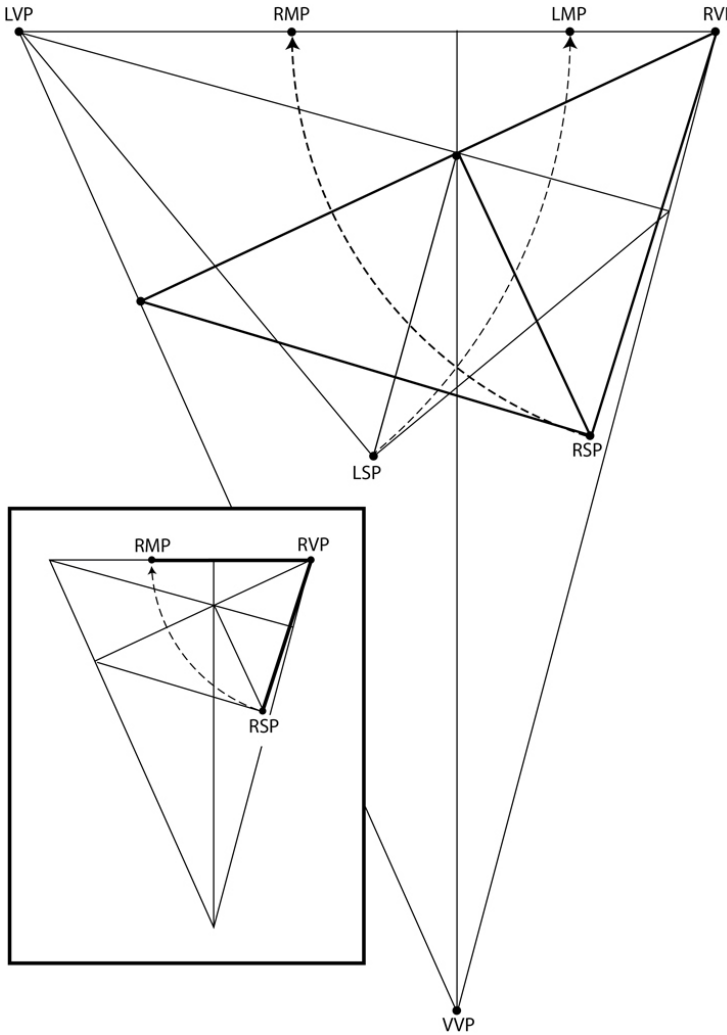


Figure 16.10 Measure the distance from right vanishing point to right station point and transfer that distance to the horizon line. **Return to text.**⏎ 217. 218.

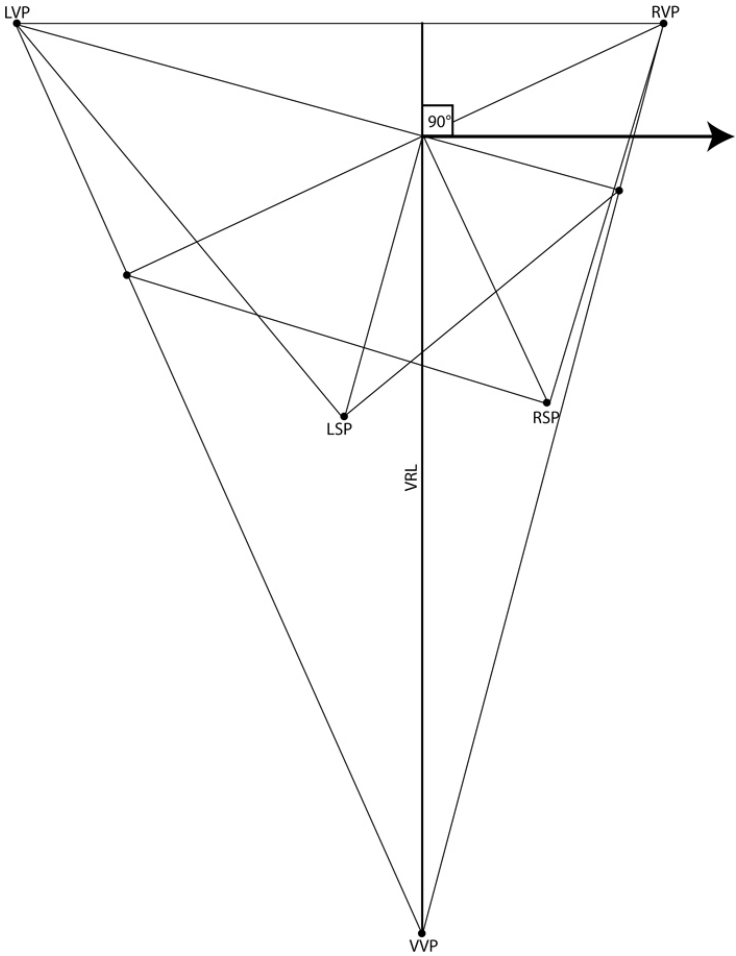


Figure 16.11 Extend a line 90° from the vertical reference line.

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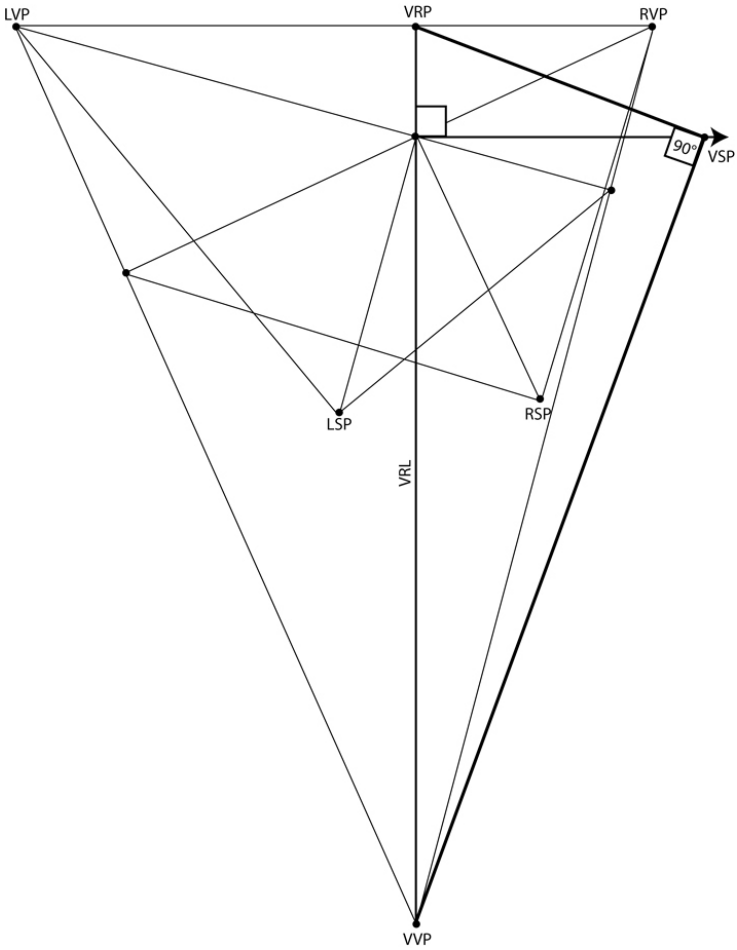

Figure 16.12 Triangulate the vertical vanishing point, the vertical reference point, and the vertical station point. **Return to text.**⏎ 219.

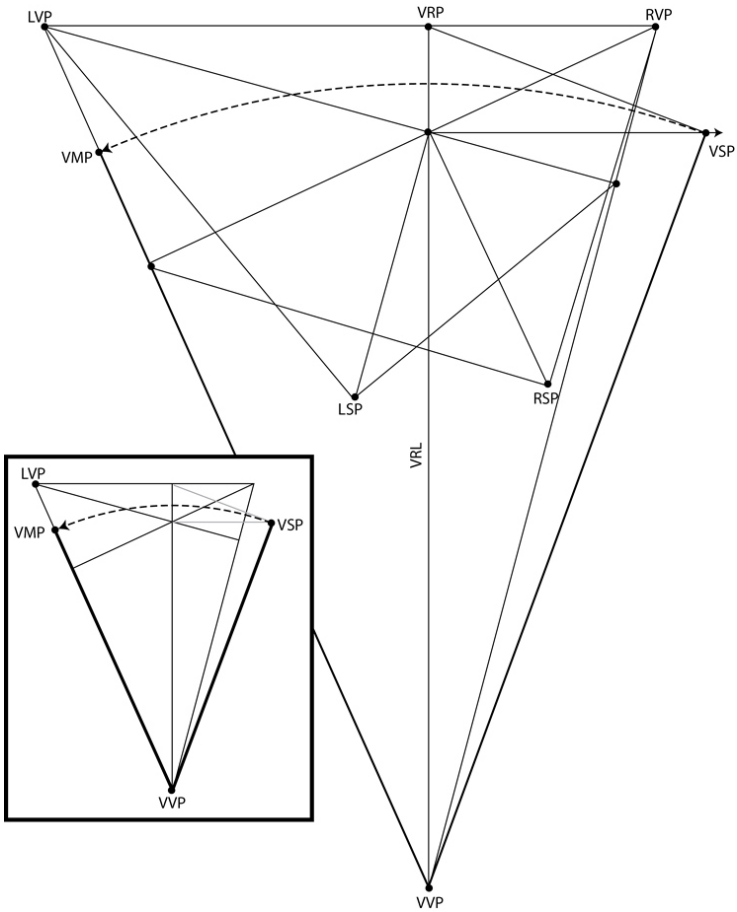

Figure 16.13 Measure the distance from the vertical vanishing point to the vertical station point. Transfer that distance to the line connecting the left vanishing point to the vertical vanishing point. **Return to text.**⏎ 220.

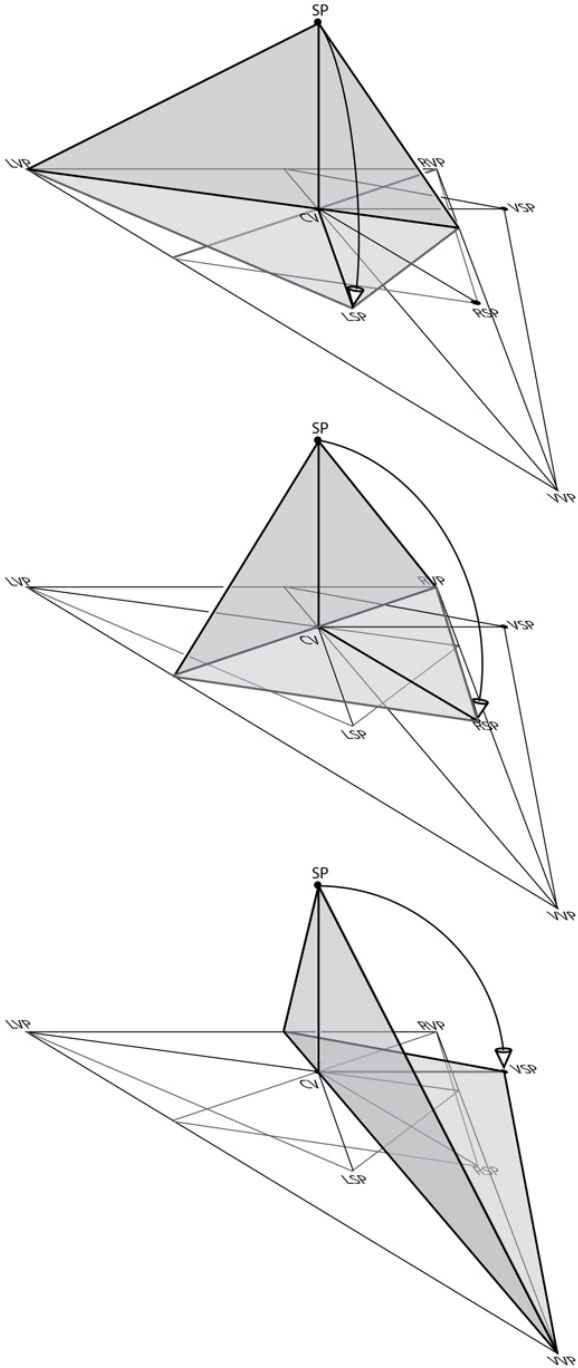

Figure 16.14 The station point is positioned in three different locations.

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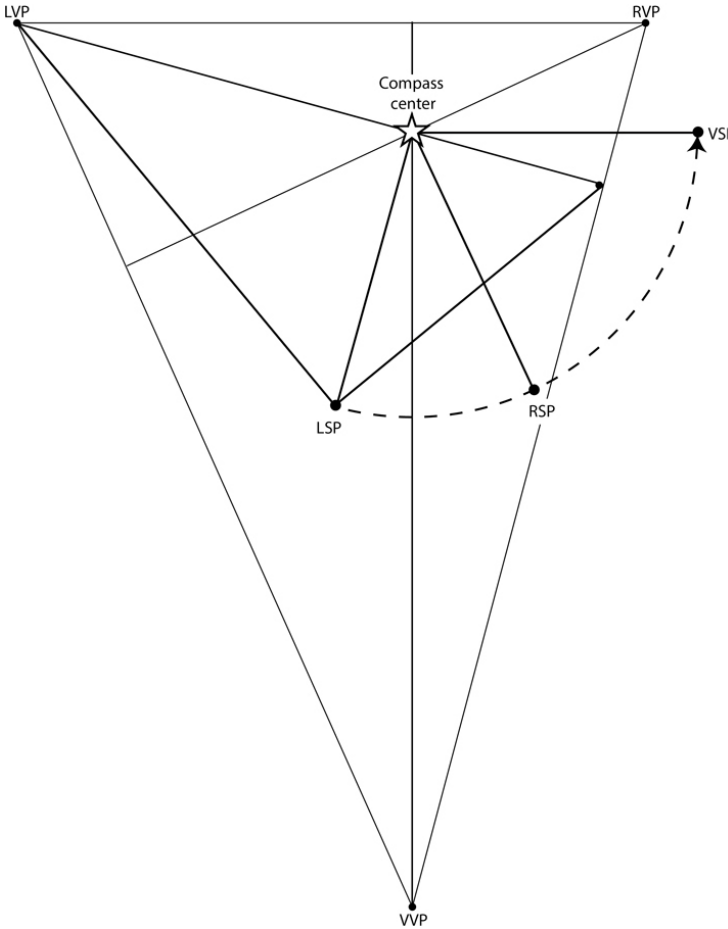


Figure 16.15 This shortcut for locating station points saves time and uses fewer lines. Return to text.⏎

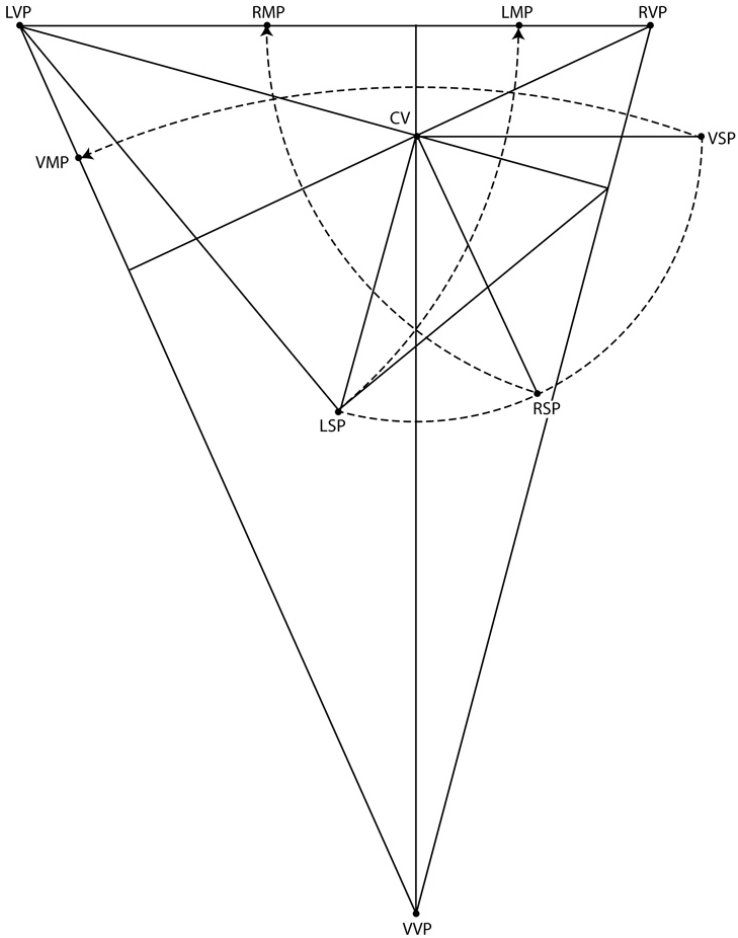


Figure 16.16 The distance from the station point to the vanishing point is the same as the distance from the vanishing point to the measuring point. **Return to text.**⏎ 224.

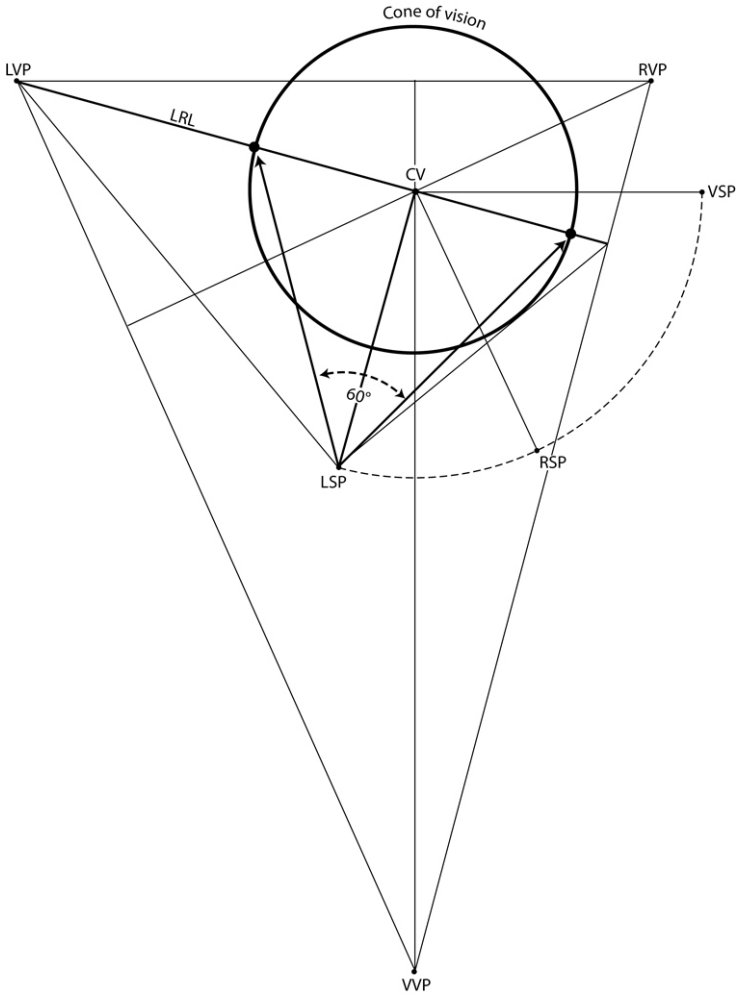


Figure 16.17 To establish the cone of vision, draw a 60° angle from the station point. **Return to text.**⏎ 225.

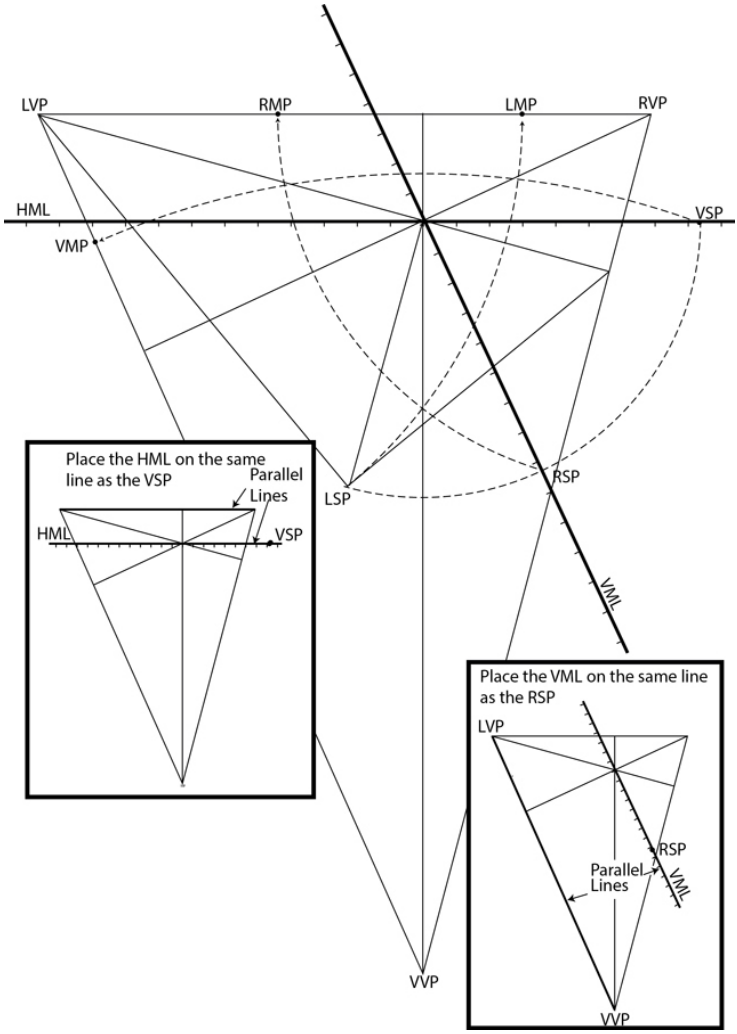


Figure 16.18 The placement of measuring lines completes the diagram. **Return to text.**⏎

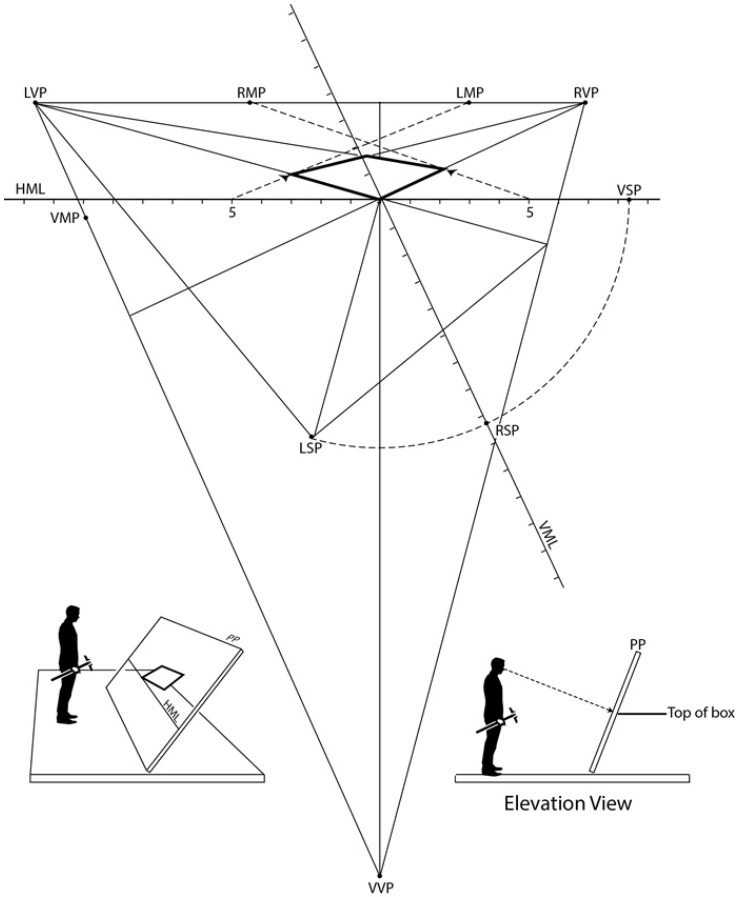


Figure 16.19 Measuring horizontal dimensions in three-point perspective is no different than measuring horizontal dimensions in two-point perspective. **Return to text.**⏎ 227.

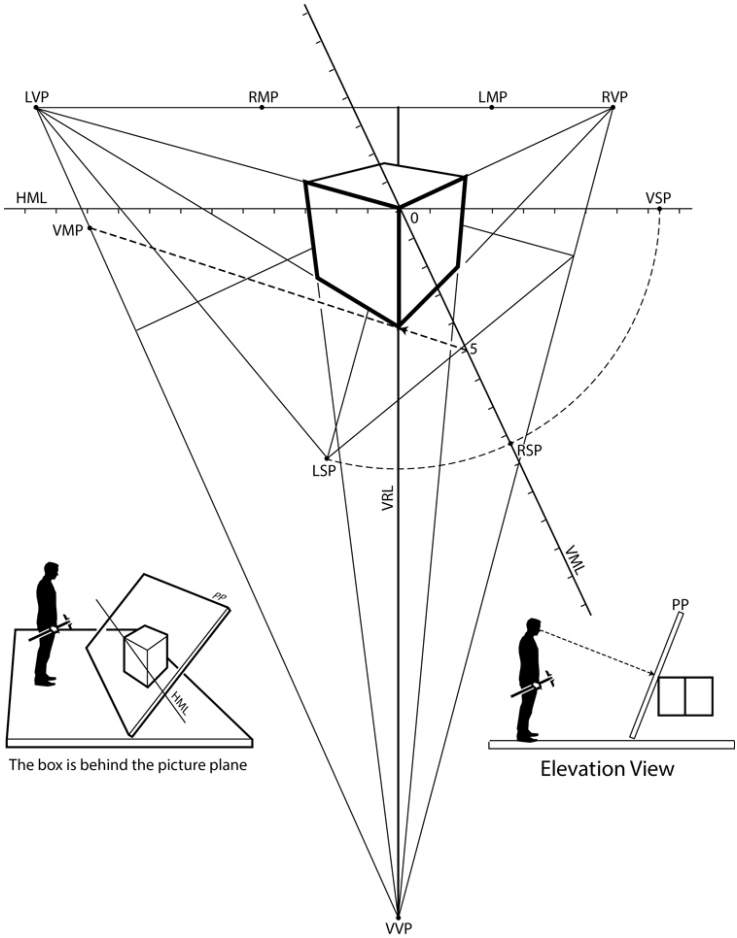


Figure 16.20 Use the vertical measuring point to measure vertical dimensions. This is a 5-unit cube. **Return to text.**⏎

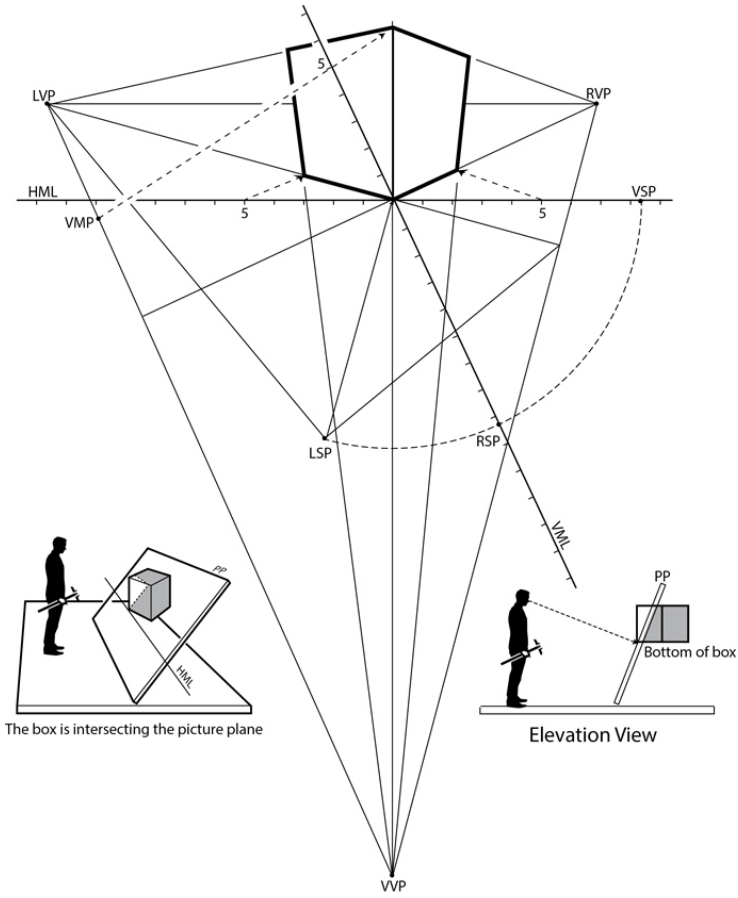


Figure 16.21 Measuring above the horizontal measuring line follows the same procedures as measuring below the horizontal measuring line. The shaded area represents the part of the box that is behind the picture plane. **Return to text.**⏎ 229.

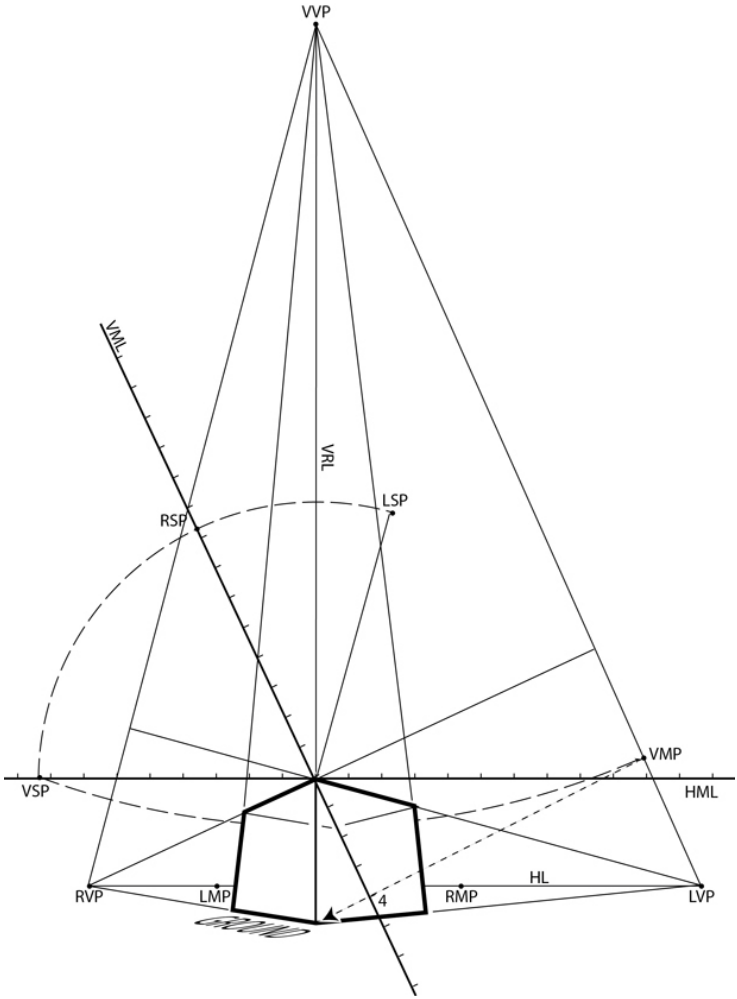


Figure 16.22 This 5-unit square is drawn on the same plane as the measuring line. **Return to text.**⏎ 230.

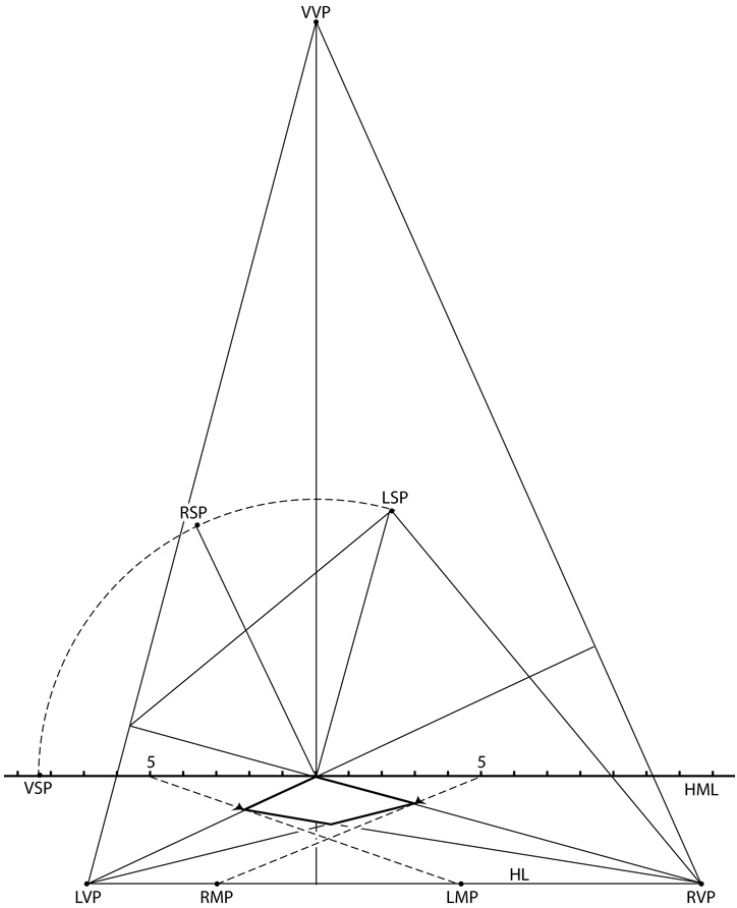


Figure 16.23 The top of this box and the horizontal measuring line are 4 units above the ground plane. **Return to text.**⏎

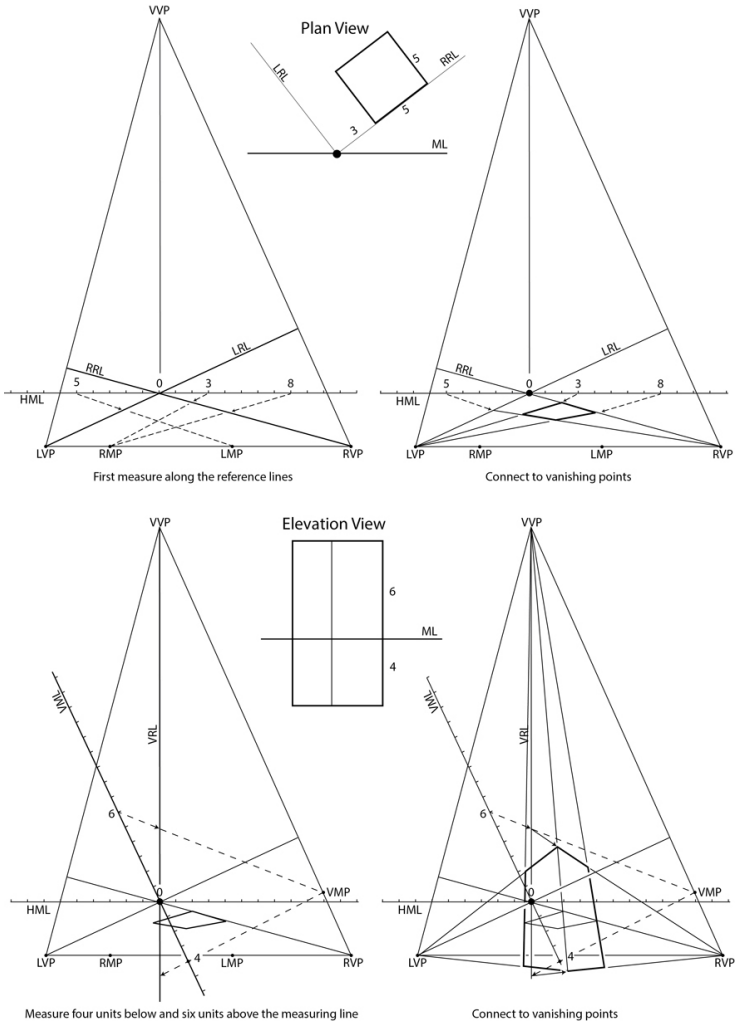


Figure 16.24Horizontal dimensions are measured at the level of the horizontal measuring line. Vertical dimensions are measured along the vertical reference line and then projected to their desired location. **Return to text.**⏎ 231.

chapter 16
Three-Point Perspective

DOI: 10.4324/9781003488101-24

208. Three-point perspective is defined by the center of vision. In one- and two-point perspective the line of sight is parallel to the ground plane; the center of vision is focused on the horizon line. In three-point perspective, the line of sight is angled to the ground plane; the center of vision is above or below the horizon line. To put it simply, the viewer is looking up or looking down in three-point perspective. If the viewer is looking up (a "worm's-eye" view), the center of vision is above the horizon line. If the viewer is looking down (a "bird's-eye" view), the center of vision is below the horizon line (Figure 16.1). All lines are foreshortened in three-point perspective; none are parallel to the picture plane.

In three-point perspective there are a myriad of variables. When considering the relationship of the viewer to the vanishing points and the object being drawn, the possibilities seem endless. It is not possible to address all the situations that might be encountered. However, the following chapters give a foundation that enables the artist to arrive at solutions to problems not covered in this book. Before addressing the more obscure and challenging aspects of three-point perspective, begin by setting up a basic three-point diagram. This is a generic set-up. Variations will be discussed later, as well as how to tailor the diagram to specific circumstances.

Three-Point Perspective Components

Picture Plane

The picture plane must be at a right angle to the line of sight. Therefore, in three-point perspective, the picture plane is angled to the ground plane (Figure 16.2).

Vanishing Points

Predictably, there are three of them: a right vanishing point, a

left vanishing point, and a vertical vanishing point (VVP). If the object's angle to the picture plane is of no concern or unknown, or the orientation of the line of sight to the ground plane is unknown, the three vanishing points can be located anywhere—well, almost anywhere. There are three caveats to keep in mind: the vertical vanishing point must be between the right and left vanishing point, the horizon line must be horizontal, and the angle at the vertical vanishing point must be less than 90° (Figure 16.3). Within these guidelines, there are many different configurations possible. How to choose the right configuration for specific needs will be covered later in this chapter. Until then, construct a generic three-point diagram with randomly placed vanishing points.

The Diagram

The following steps describe the construction of a bird's-eye view. The steps for a worm's-eye view are the same, only upside down. A worm's-eye view diagram is a bird's-eye view diagram turned 180°.

Center of Vision

Once the three vanishing points have been established, the location of the center of vision is predetermined. Its position is dictated by the geometry. First draw three lines (reference lines) at right angles from the lines connecting each vanishing point: a left reference line (LRL), a right reference line (RRL), and a vertical reference line (VRL). The reference lines connect to the left vanishing point, right vanishing point, and vertical vanishing point, respectively. These three reference lines intersect at the same spot, at the center of vision (Figure 16.4).

212. The intersection of each reference line with their orthogonal creates a reference point: a left reference point (LRP), right reference point (RRP), and a vertical reference point (VRP). These reference points are needed to locate the station points.

Station Points

Each vanishing point has a dedicated station point. The left station point (LSP), right station point (RSP), and vertical station point (VSP) are necessary to locate measuring points and define the cone of vision.

Left Station Point

Like the center of vision, the location of the station points is predetermined. Finding the station points can be a little tricky. First, from the center of vision, draw a line 90° from the left reference line (Figure 16.5).

213. Here is the tricky part. From the center of vision, a line needs to be triangulated between the left vanishing point, the left reference point, and the line drawn in Figure 16.5. A triangle is the best tool for this job. The left reference point is at the intersection of the left reference line and the orthogonal. The station point's location can vary depending on the diagram. Its placement is determined by the angles created in this procedure. Follow them carefully (Figure 16.6).

Left Measuring Point

Measure the distance from the left vanishing point to the station point and transfer that distance to the horizon line using a compass or a ruler. The distance from the vanishing point to the station point is the same as the distance from the vanishing point to the measuring point (Figure 16.7).

Right Measuring Point

Use the right reference line to locate the right station point (Figure 16.8–9). Transfer the distance from the station point to the horizon line (Figure 16.10).

Vertical Measuring Point

Use the vertical reference line to locate the vertical station point (Figure 16.11–12). Measure the distance from the vertical

vanishing point to the vertical station point. Transfer that distance to the line that connects the vertical vanishing point to the left vanishing point. The vertical measuring point is not on the horizon line (Figure 16.13).

The Shortcut

It may seem strange that there are three station points—and it should. The station point represents the viewer, and there is only one viewer. So why are there three station points? The answer is simple: there are not three station points. Each station point is the same point. The left, right, and vertical station point are all equal distances from the picture plane. Each represents the same point in space. The same station point has been placed in three different locations, enabling it to find three different measuring points (Figure 16.14).

223. This shortcut is based on all three of the station points being equal distances from the picture plane. Locate one station point, and then repeat that distance to find the others. After finding the first station point, use a compass to find the other two (Figure 16.15). Then add the measuring points using the previously described method (Figure 16.16)

Cone of Vision

The cone of vision is, as always, 60°. Any station point can be used to determine the cone of vision (Figure 16.17). The left, right, or vertical station point will all give the same result.

Measuring Line

There are two measuring lines in three-point perspective: a horizontal and a vertical measuring line. The horizontal measuring line (HML) is used for measuring lines parallel to the ground plane. The vertical measuring line (VML) is used for measuring lines perpendicular to the ground plane. For the geometry to be correct, it is critical that the measuring line be parallel to the line the measuring point is on. The right and left

measuring points are on the horizon line, so the measuring line must be horizontal. The vertical measuring point is on an angled line, so the measuring line must be at the same angle. A line perpendicular to the right reference line will be parallel to the line the measuring point is on. The line the right station point is on becomes the vertical measuring line (Figure 16.18).

226. Congratulations—the three-point perspective diagram is finished. Now it is time to draw something.

Drawing a Cube

For the first three-point example, draw a 5-unit cube, its front corner touching the picture plane and tangent with the center of vision.

Horizontal Dimensions

Measuring horizontal lines (the top of the box) in three-point perspective is done exactly the same as two-point perspective (Figure 16.19). The same rules apply. Confirm that what is being measured and the measuring line are on the same plane. This can be tricky in three-point perspective, as the measuring line is not always on the ground.

Vertical Dimensions

All vertical lines connect to the vertical vanishing point. To measure these lines, use the vertical measuring line and the vertical measuring point. In this example, the line being measured is the vertical reference line.

From the center of vision, count 5 units along the vertical measuring line. Then, using the vertical measuring point, project that dimension to the vertical reference line. Connect to the vertical measuring point, intersecting the vertical reference line. This intersection represents 5 units in perspective (Figure 16.20).

228. The vertical measuring point is used for all vertical measurements. It is critical that the object being measured is on

the same plane as the measuring line. When measuring vertical dimensions, this can be difficult to determine. A safe bet is using the vertical reference line for all vertical measurements. The vertical reference line is always on the same plane as the vertical measuring line. Measure the height along the vertical reference line, then project that distance (using a vanishing point or reference point) to its desired location. This takes some practice.

Ground Plane

In Figure 16.20 the top of the cube is at the level of the horizontal measuring line. It is 5 units above the ground plane. If the horizontal measuring line is on the ground plane, measure vertical dimensions up instead of down. The measurements are still along the vertical measuring line, still projected to the vertical measuring point, and still placed along the vertical reference line. Now the *bottom* of the box is on the same plane as the horizontal measuring line, and the *top* of the box is 5 units above (Figure 16.21).

Worm's-Eye View

A bird's-eye view diagram turned upside down becomes a worm's-eye view diagram. The diagram is the same, only rotated 180°. All the guidelines for constructing the diagram and for measuring objects still apply. When drawing a worm's-eye view, there are, however, a couple of issues to keep in mind when measuring and establishing the ground plane.

Establishing the Ground Plane

Measuring Width

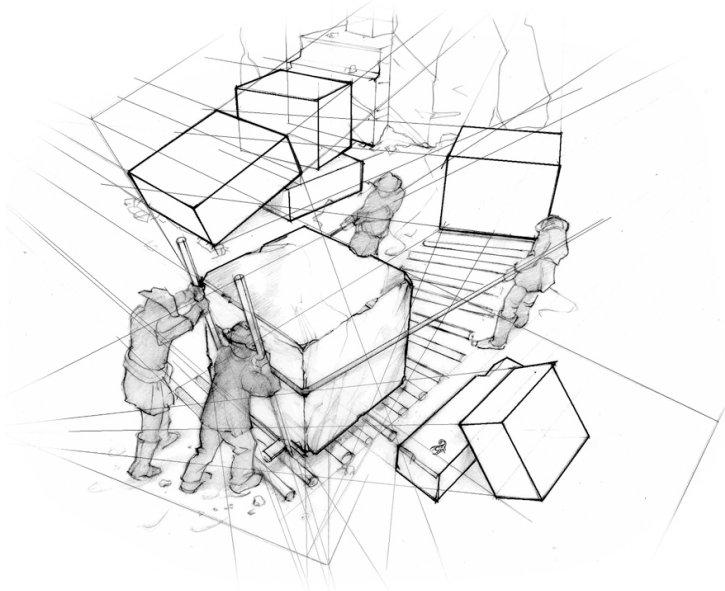
The horizontal measuring line is tangent with the center of vision. The center of vision, being above the horizon line, requires that all horizontal measurements take place above the

ground plane (Figure 16.22). For example, if the horizontal measuring line is 4 units above the ground plane, make all the horizontal measurements at that level.

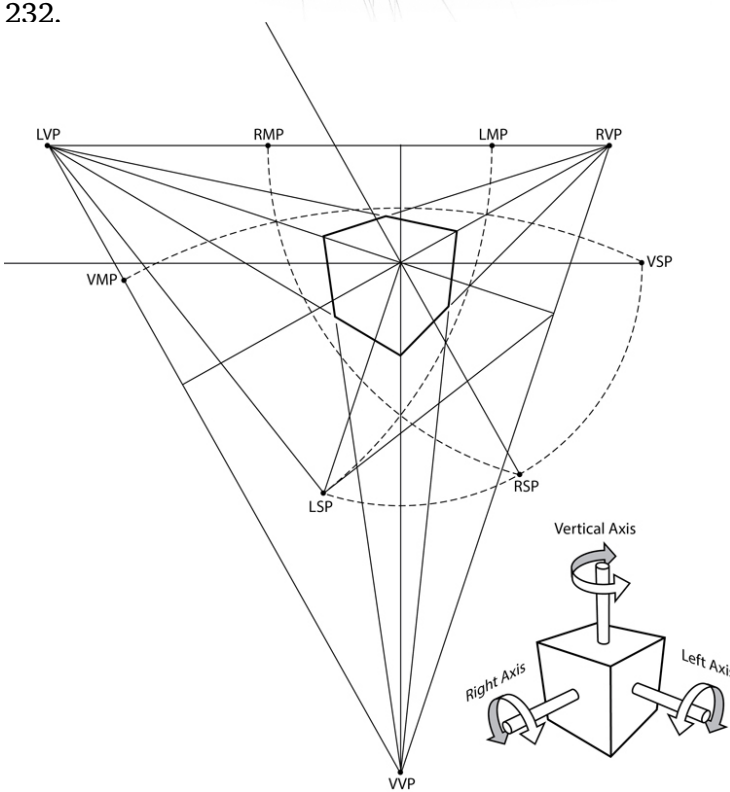
Measuring Height

For an object to be sitting on the ground (as opposed to floating above the ground), its base must be at or below the horizon line. Once the width and depth of the object have been established, measure down to the ground plane. The ground plane can be located anywhere. The farther that is measured down, the higher the horizontal measuring line will be. How tall the object is made decides where the ground is (Figure 16.23).

All the previous examples have had the corner of the box touching the center of vision. Before moving on, here is an example where the box is in a different location. The plan and elevation views describe its position (Figure 16.24).



232.


LVP
RMP
LMP
RVP
VSP
VMP
LSP
RSP
VVP
Vertical Axis
Right Axis
Left Axis

Figure

17.1 An object can rotate along three axis points. **Return to text.**⏎ 234.

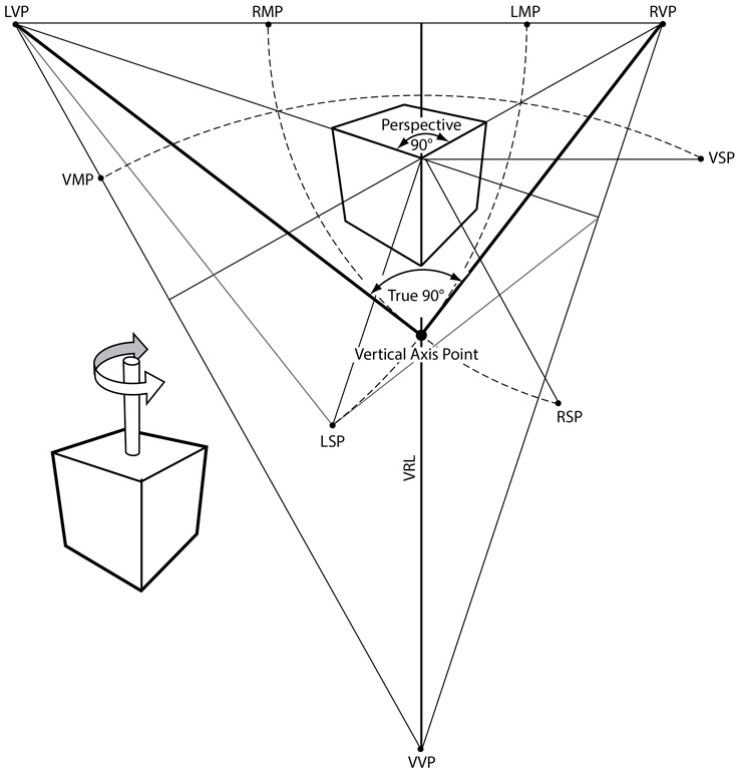


Figure 17.2 True angles for all horizontal lines are found at the vertical axis point. **Return to text.**⏎ 235.

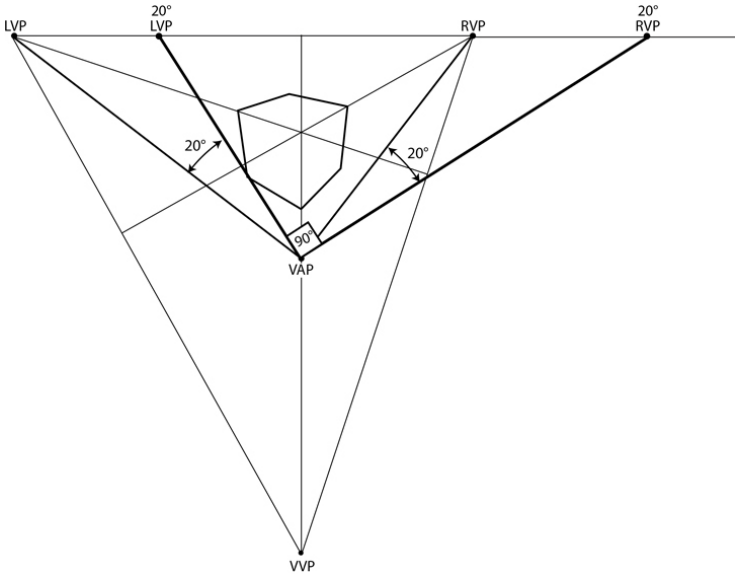
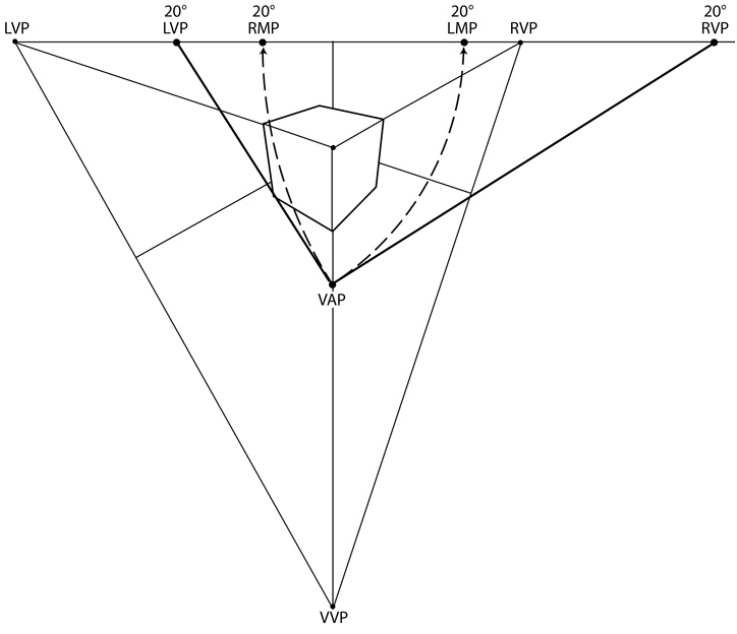


Figure 17.3 Angles projected from the vertical axis point create vanishing points that draw those same angles in perspective. These two new vanishing points are rotated 20° clockwise. **Return to text.**⏎ 236.



Figure

17.4 To locate measuring points, measure the distance from the vanishing points to the vertical axis point. Transfer that distance to the horizon line. **Return to text.**⏎

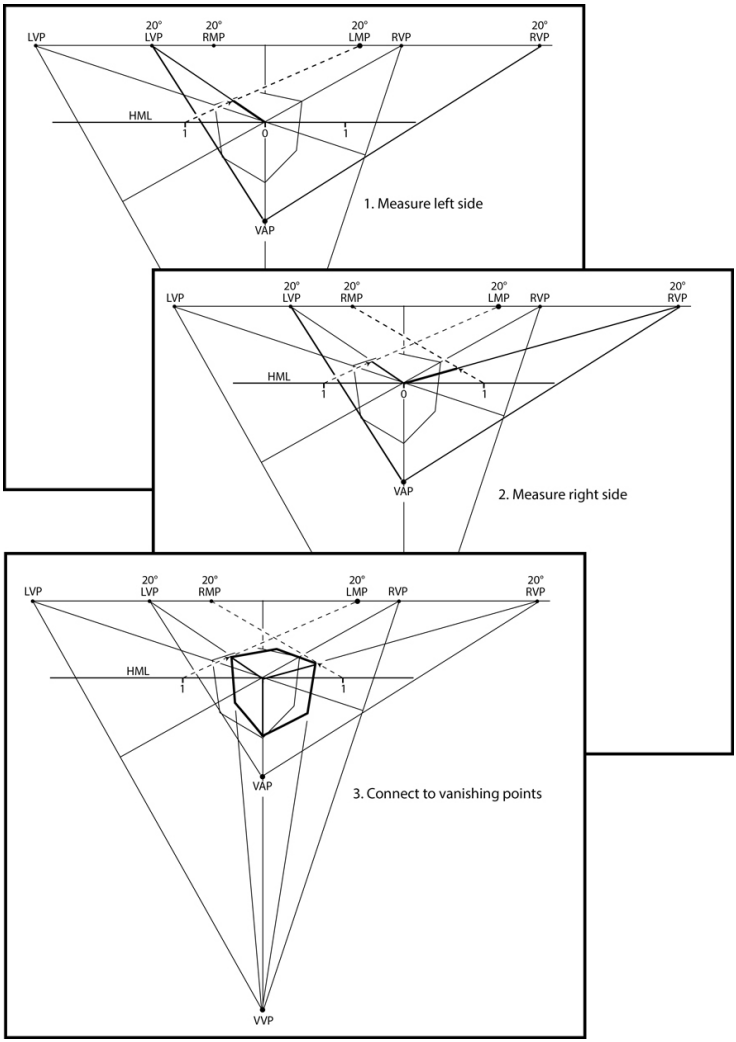


Figure 17.5 Measuring horizontal lines is accomplished using the same technique as two-point perspective. **Return to text.**⏎

237. 238.

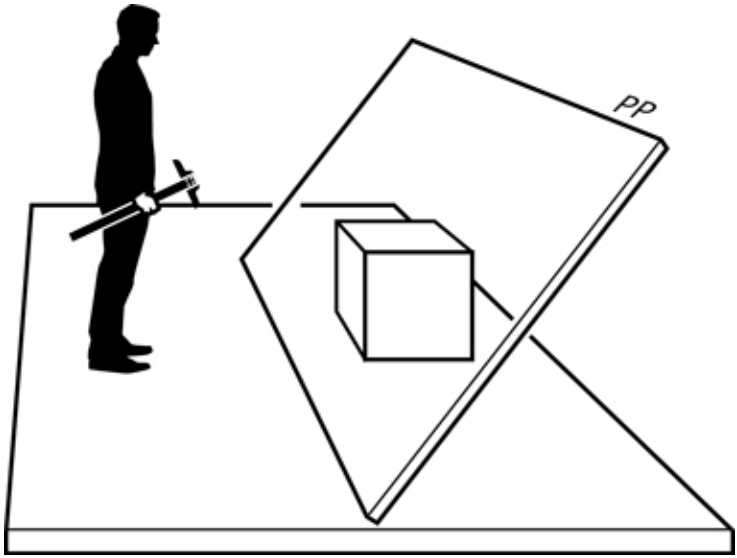


Figure 17.6 Looking down at a one-point cube. **Return to text.**⏎

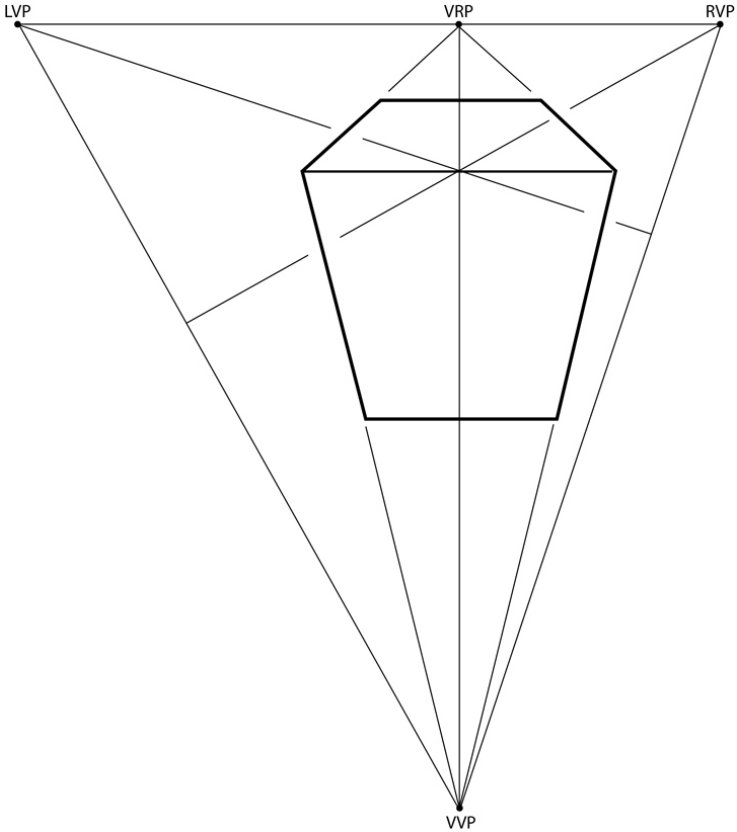


Figure 17.7 When drawing a one-point perspective box in three-point perspective, foreshortened lines connect to the vertical vanishing point and the vertical reference point. Horizontal lines are parallel to the picture plane and have no vanishing point. **Return to text.**⏎ 239.

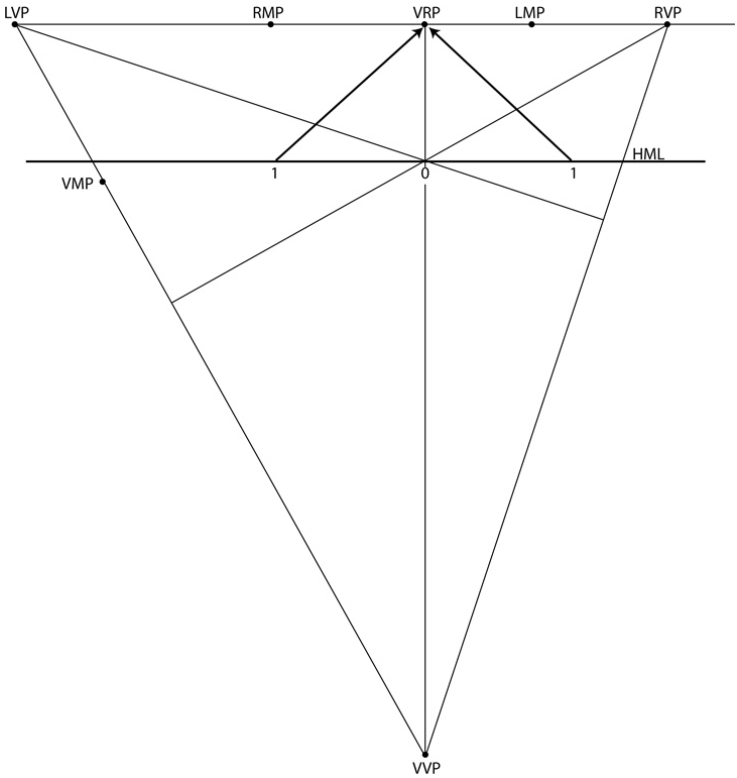


Figure 17.8 Measure width along the horizontal measuring line and connect to the vertical reference line. This box is 2 units wide—1 unit to the left and 1 unit to the right—with its center at the center of vision. **Return to text.**⏎ 240.

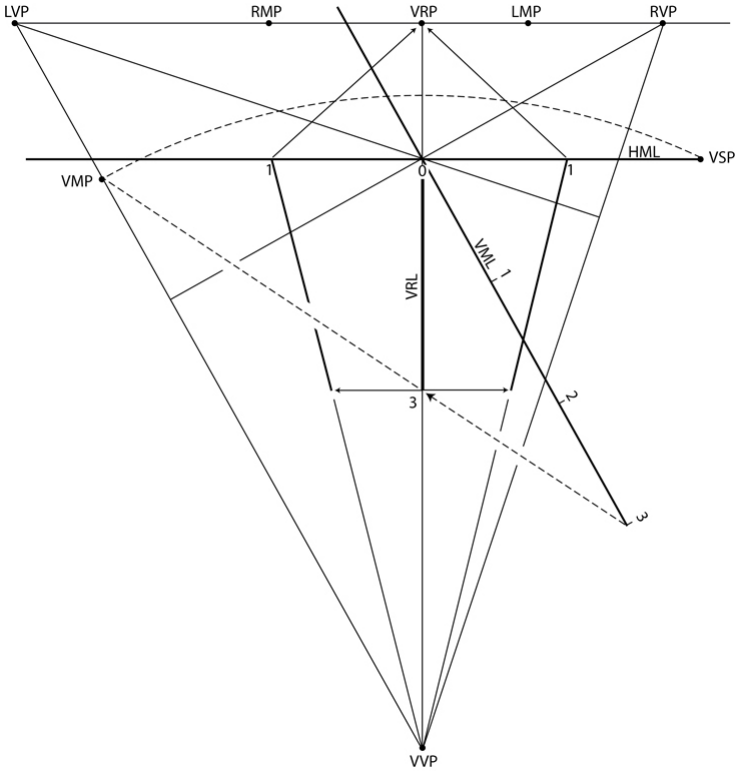


Figure 17.9 Measure the height along the vertical reference line. The bottom of the box is 3 units below the horizontal measuring line. **Return to text.**⏎ 241.

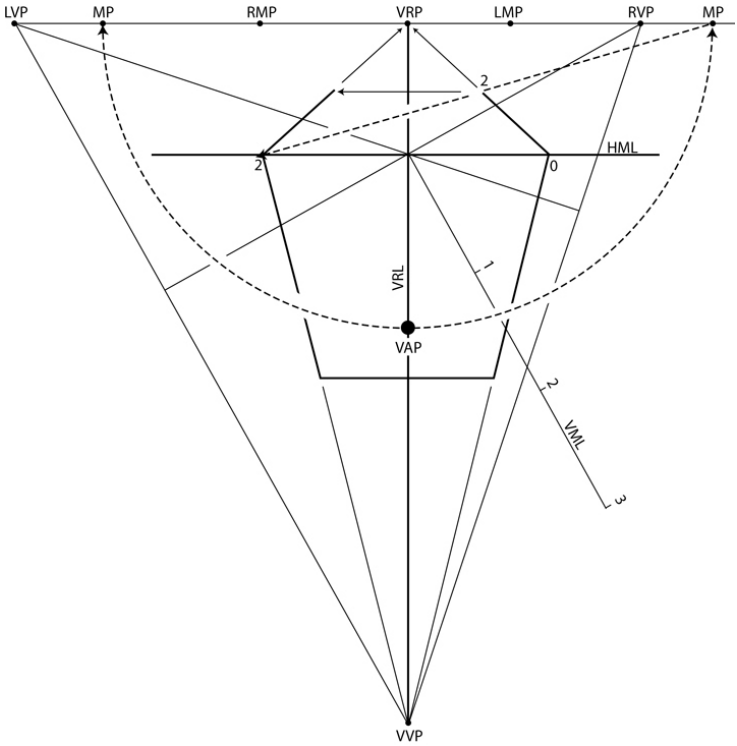
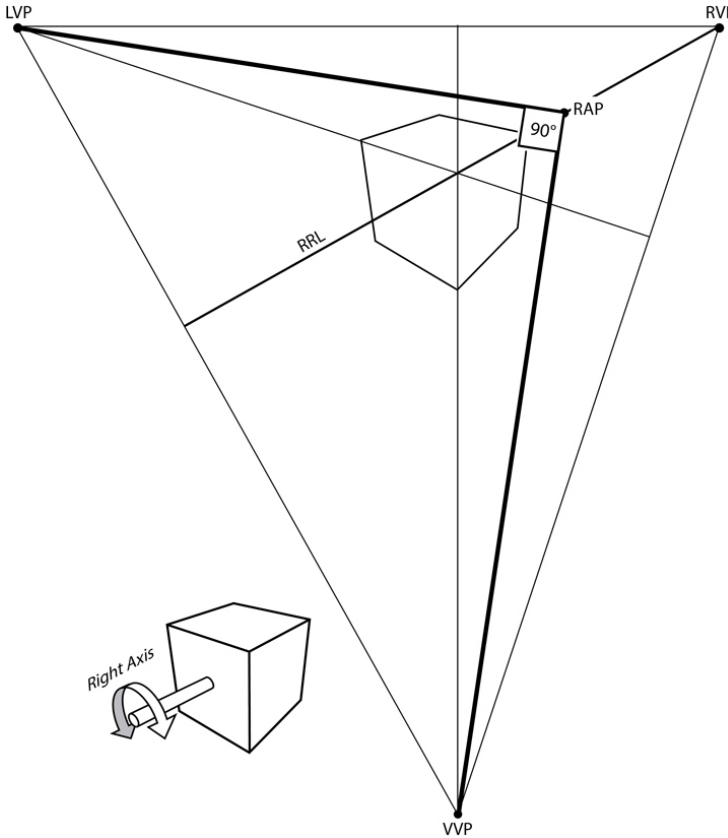


Figure 17.10 Find measuring points using the vertical axis point and measure per one-point perspective. **Return to text.**⏎



242.

Figure 17.11 The right axis point must be placed on the right reference line, 90° from the left and vertical vanishing point. **Return to text.**⏎ 243.

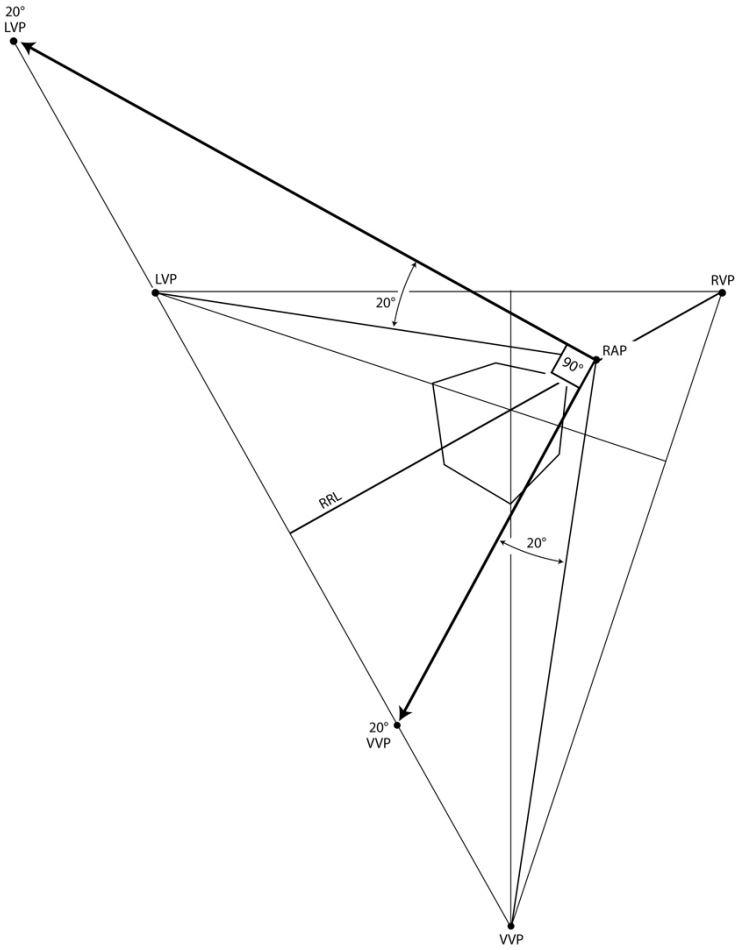


Figure 17.12 Using the right axis point, create two new vanishing points by rotating the 90° angle. These new vanishing points are rotated 20° clockwise from the original. **Return to text.**⏎ 244.

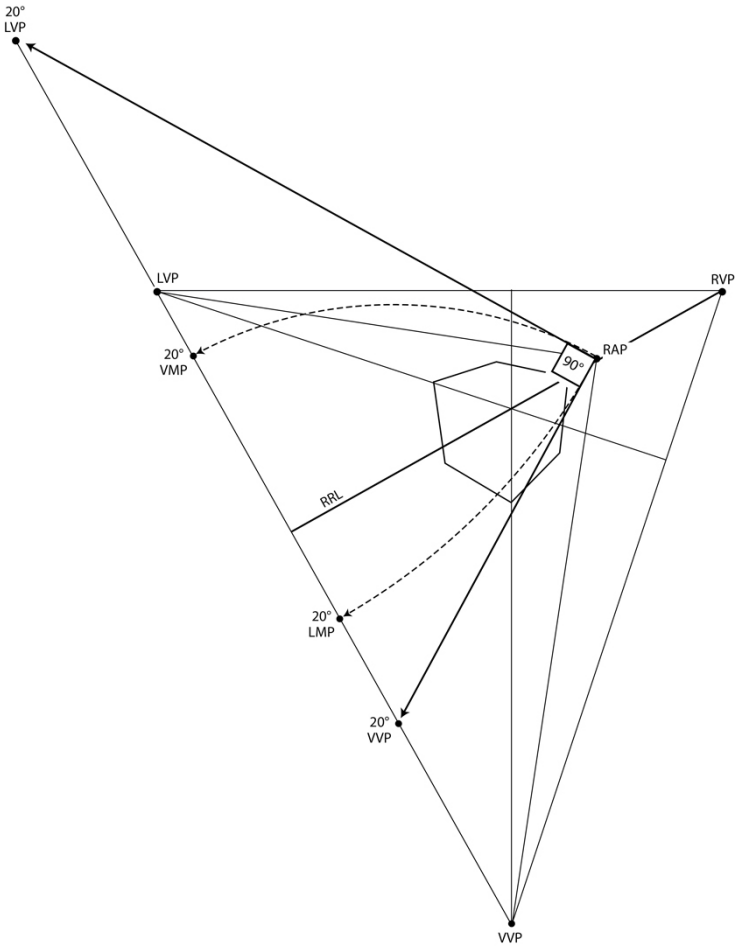


Figure 17.13 To establish the measuring points, measure the distance from the vanishing point to the right axis point. Project that distance to the line connecting the vanishing points. **Return to text.**⏎ 245.

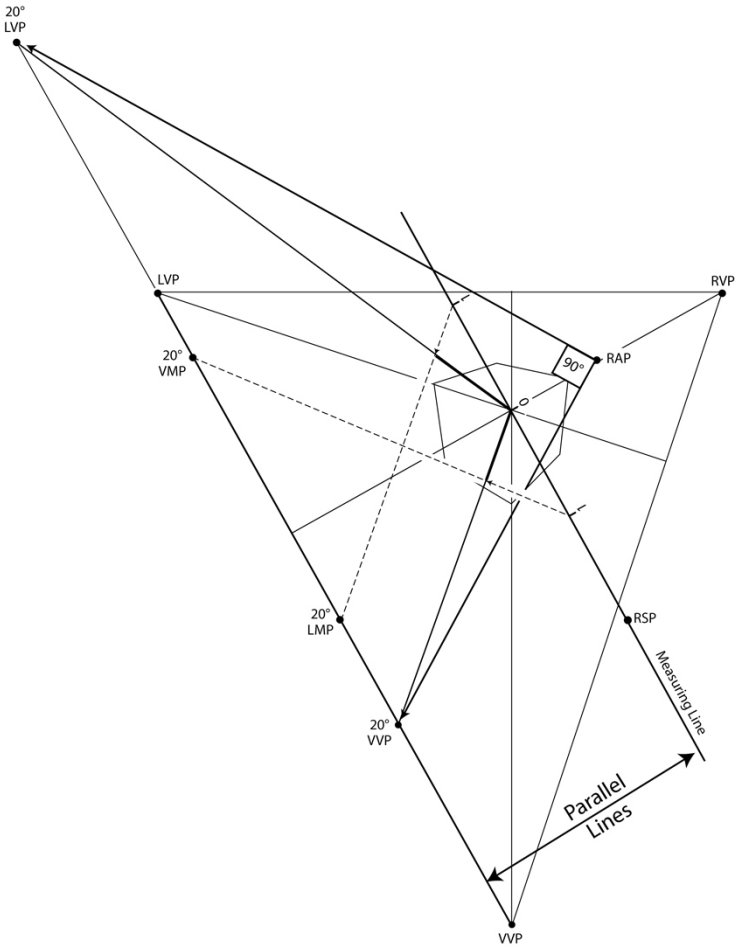
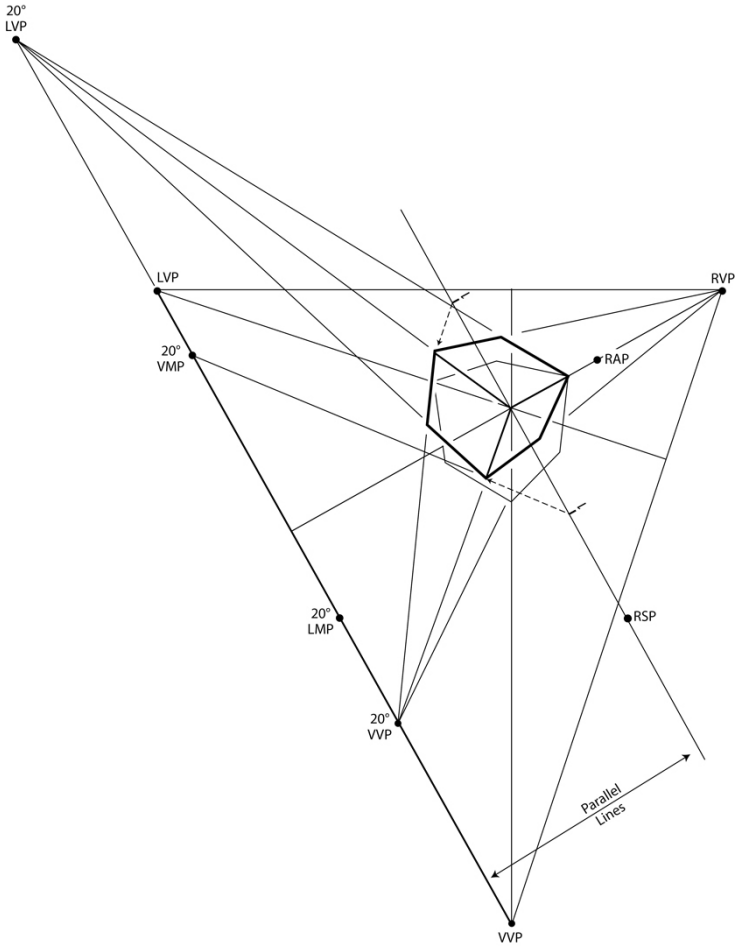


Figure 17.14 The measuring line must be parallel with the line the measuring points are on (the line parallel to the right station point becomes the measuring line). **Return to text.**⏎



246.

Figure 17.15 Connect lines to vanishing points to complete the box. **Return to text.**⏎ 247.

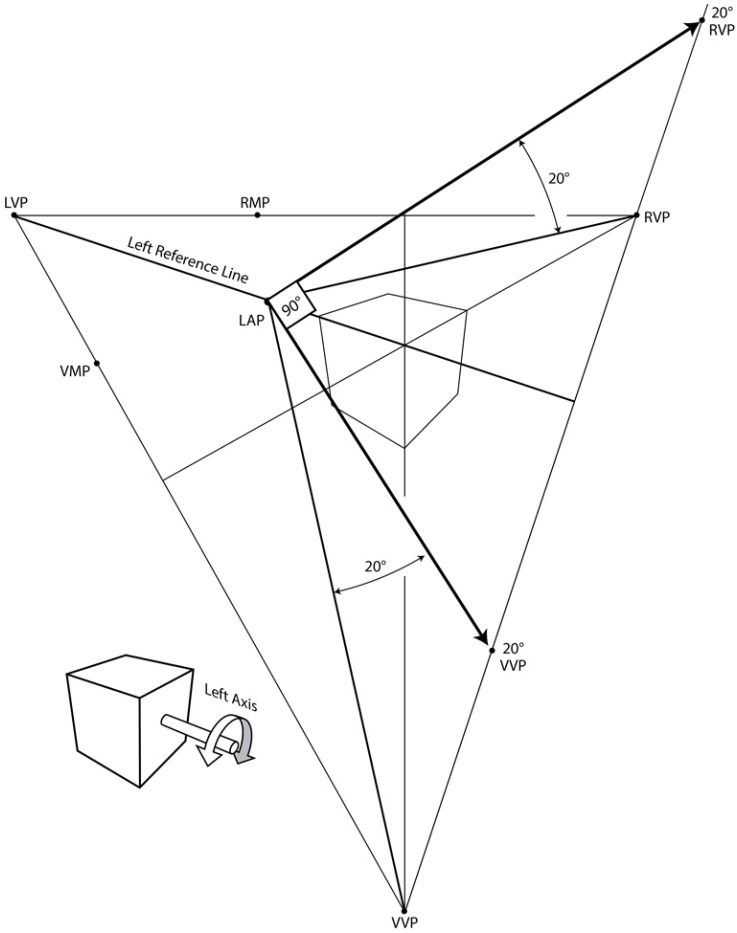


Figure 17.16 Use the left axis point to find the new vanishing points. **Return to text.**⏎

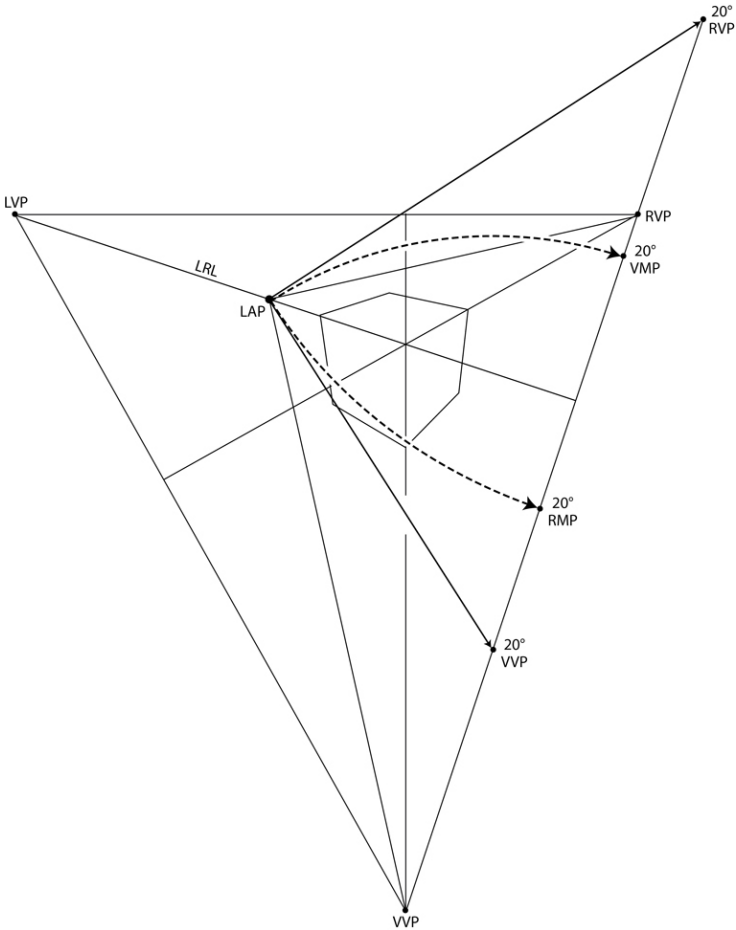


Figure 17.17 To establish the measuring points, measure the distance from the vanishing point to the left axis point. Project that distance to the line the vanishing points are on. **Return to text.**⏎ 248.

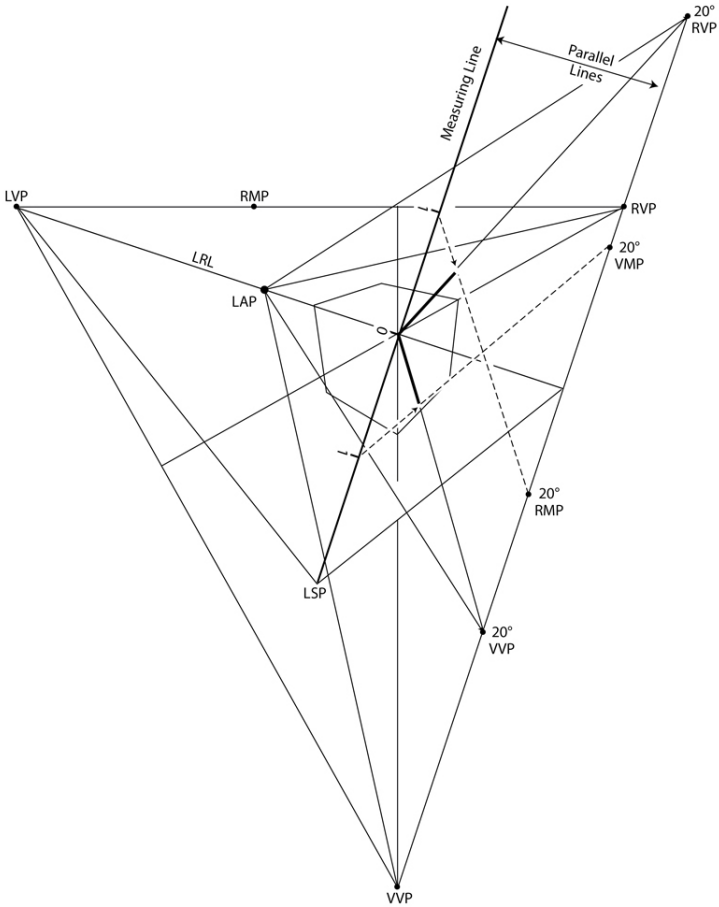


Figure 17.18 The measuring line must be parallel with the line the measuring points are on, and the line being measured must be on the same plane as the measuring line. **Return to text.**⏎ 249.

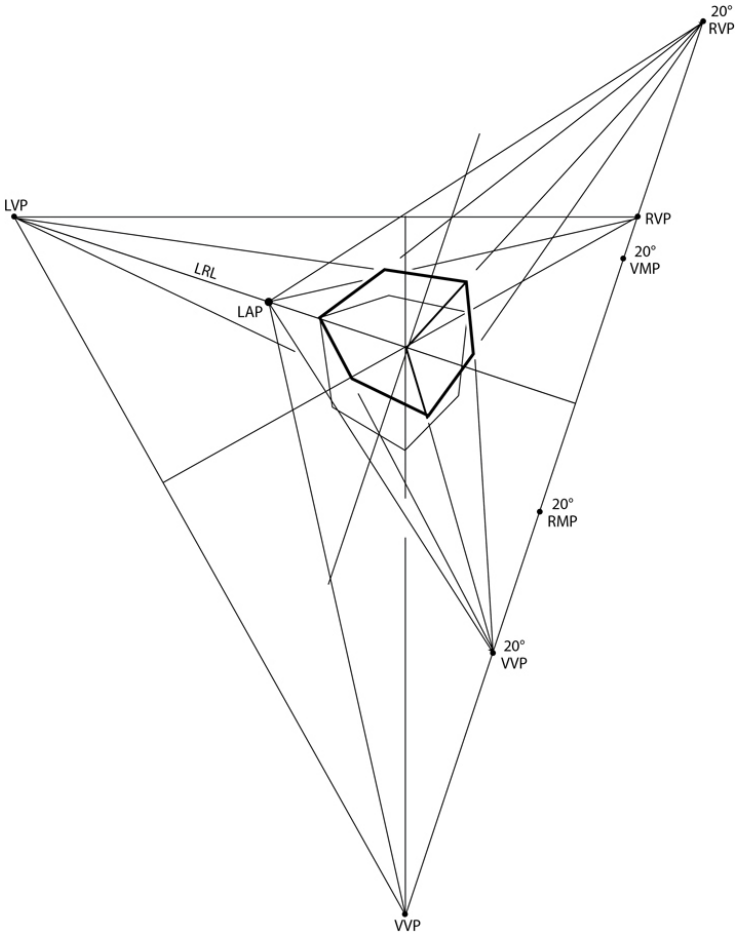


Figure 17.19 Connect to vanishing points to complete the box. Return to text. 250. 251.

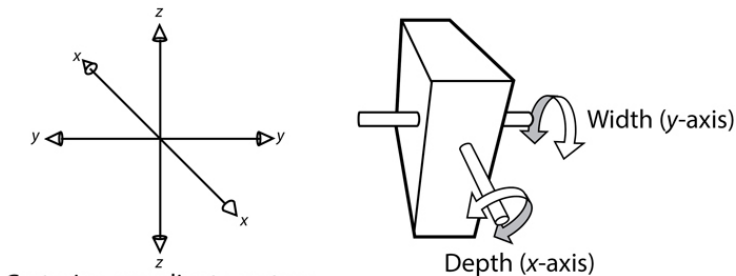
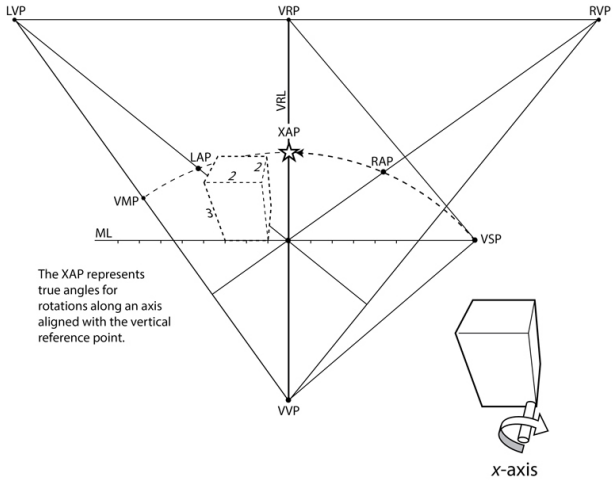


Figure 17.20 Using the Cartesian coordinate system to define one-point perspective angles. Return to text.



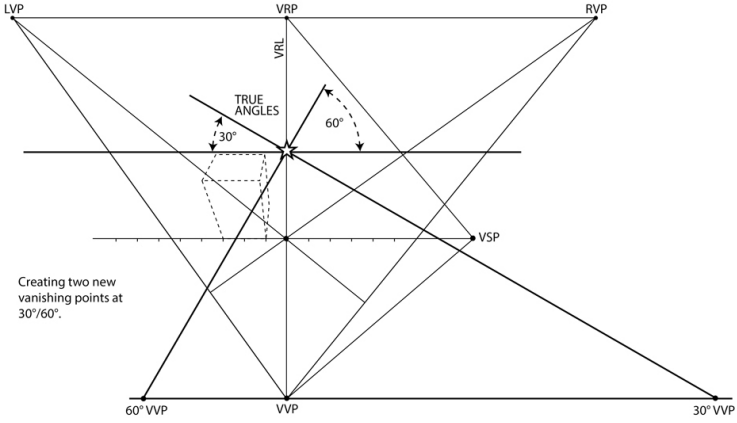
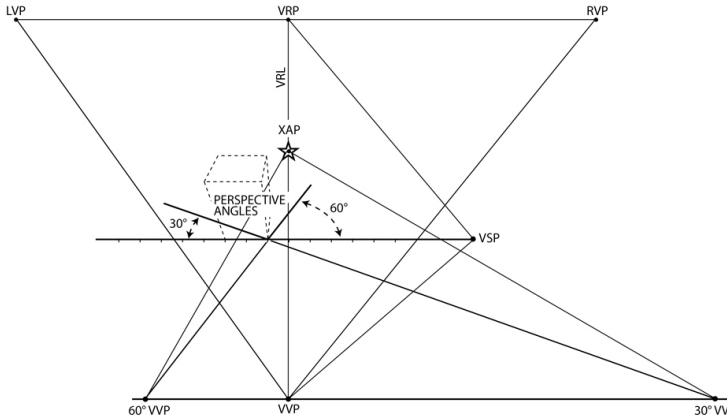


Figure 17.21 The 60° and 30° vanishing points are aligned horizontally with the vertical vanishing point. **Return to**



text.↵

Figure 17.22 The perspective angles drawn from the two new vanishing points reflect the true angles plotted at the *x*-axis point. Return to text.↵

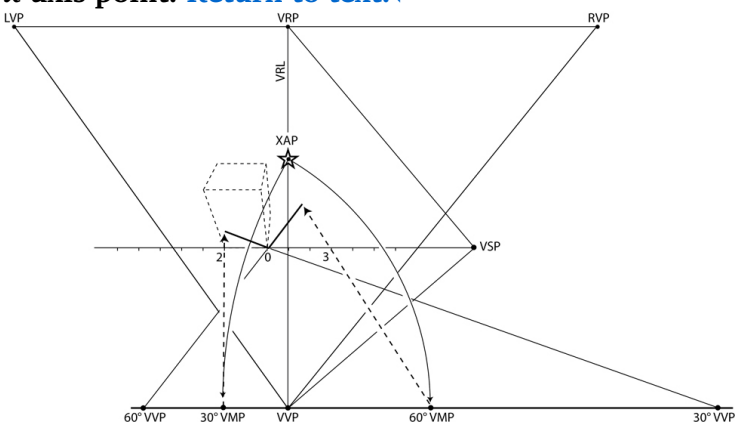


Figure 17.23 Find measuring points by measuring the distance from the new vertical vanishing points to the *x*-axis point. Then transfer it to the horizontal line. Return to text.↵ 254.

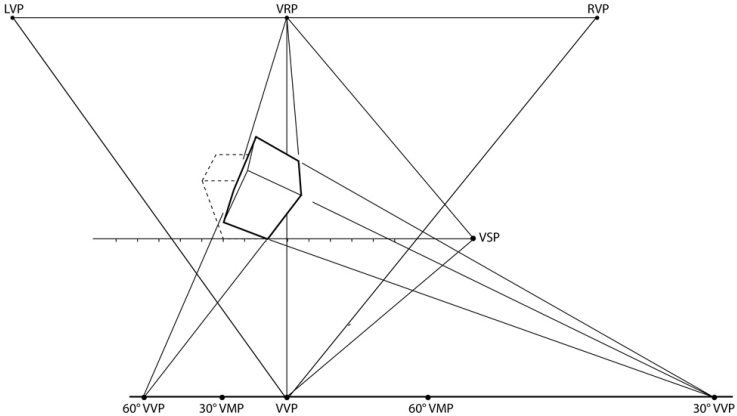
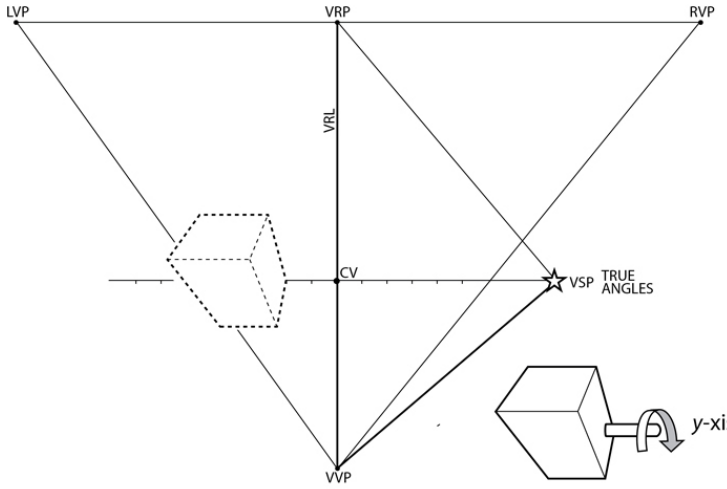


Figure 17.24 Connect lines to vanishing points to complete the box. **Return to text.**⏎



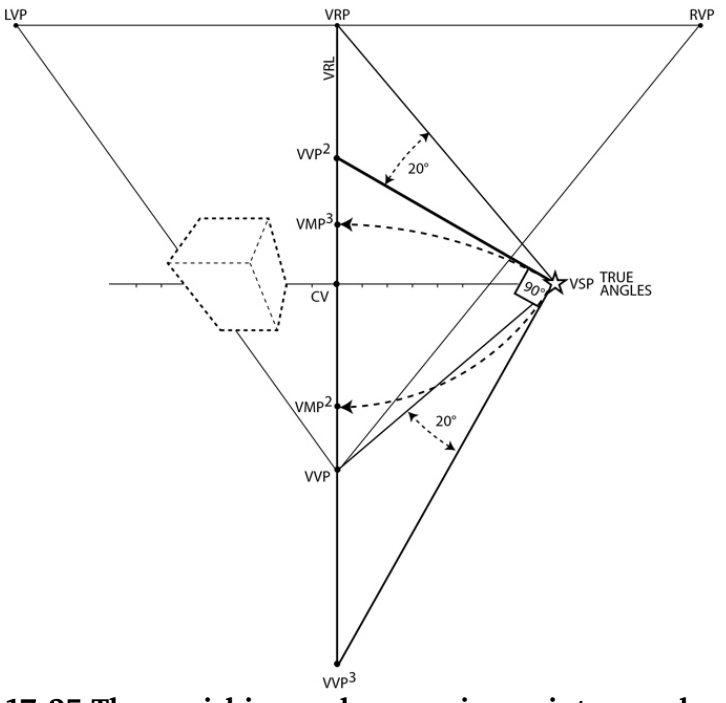


Figure 17.25 The vanishing and measuring points are placed on the vertical reference line. True angles are found at the vertical station point. **Return to text.**⏎

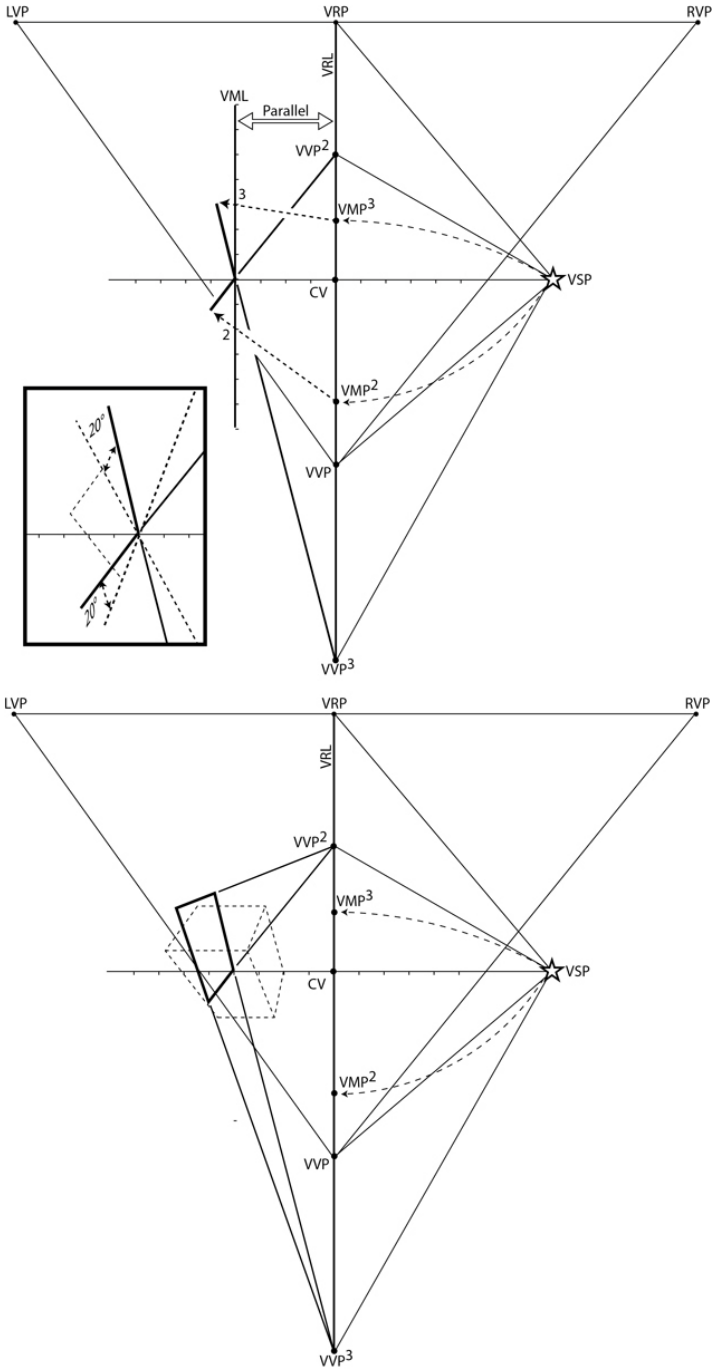


Figure 17.26 Since the measuring points are on a vertical line the

measuring line must also be vertical. This box is tilted 20° clockwise. **Return to text.**⏎

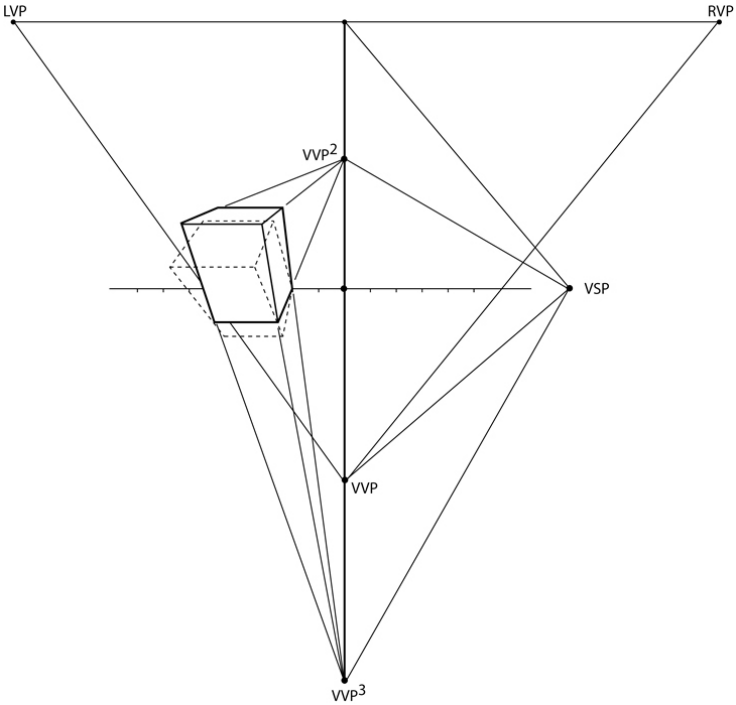
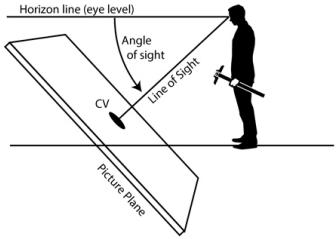
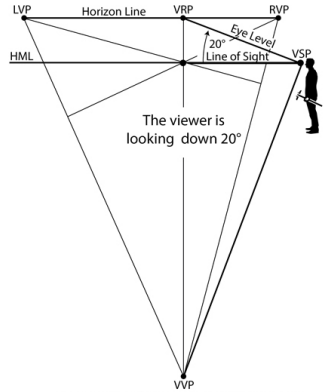


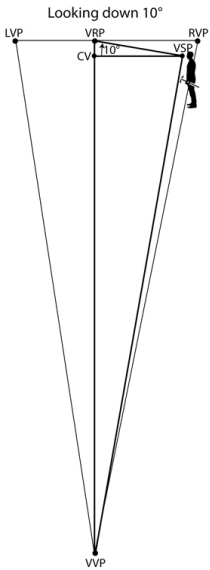
Figure 17.27 Connect to the vanishing points to complete the box. **Return to text.**⏎



The angle between the horizon line and the line of sight determines the angle from which the viewer is looking.



Here's how it translates to a three point diagram.



The closer the center of vision is to the vertical vanishing point, the more extreme the angle from which the viewer is looking.

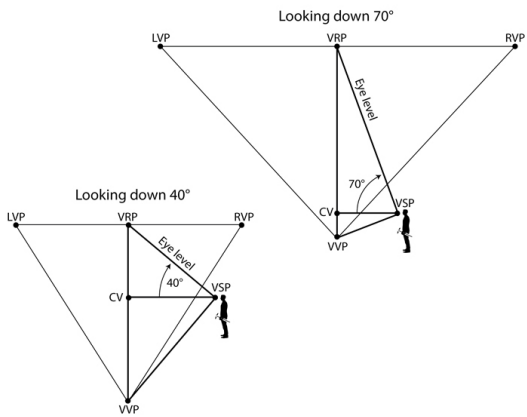


Figure 17.28 The angle of sight is determined at the vertical station point. **Return to text.**⏎ 258. 259.

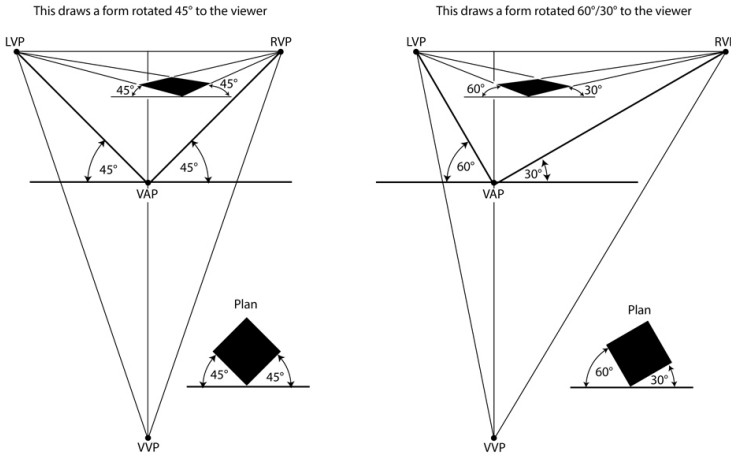


Figure 17.29 The angle of the object to the picture plane is defined at the vertical axis point. **Return to text.**⏎ 260.

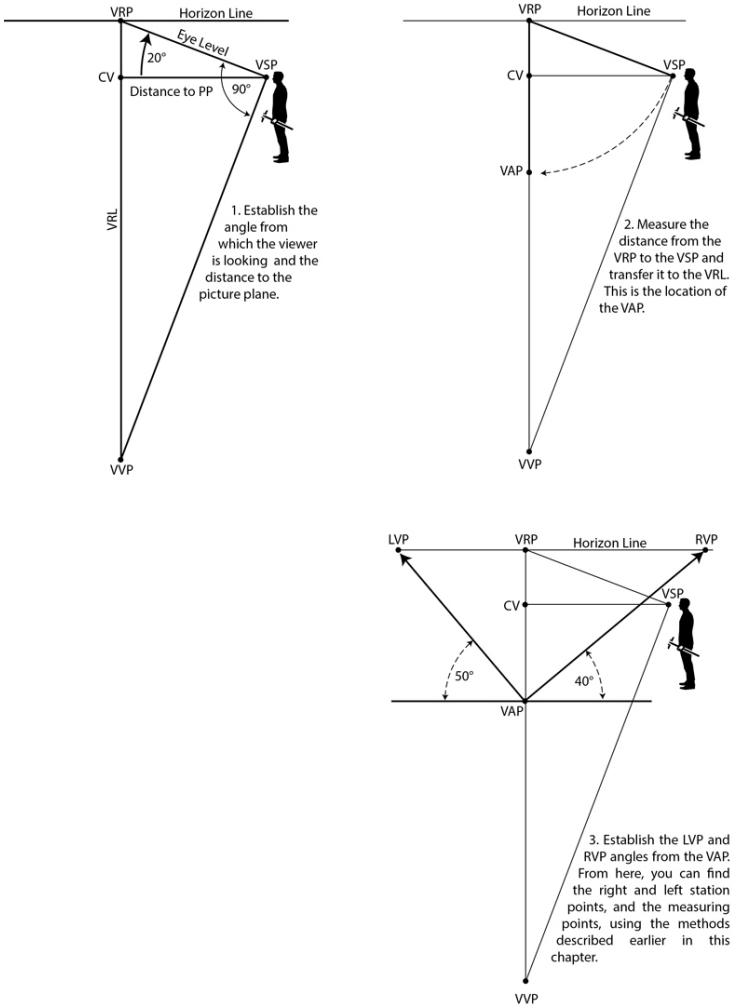


Figure 17.30 This three-point diagram begins at the vertical station point. The viewer is looking down at a 20° angle. The object being drawn is at a 50°/40° angle to the picture plane. **Return to text.**⏎ 261.

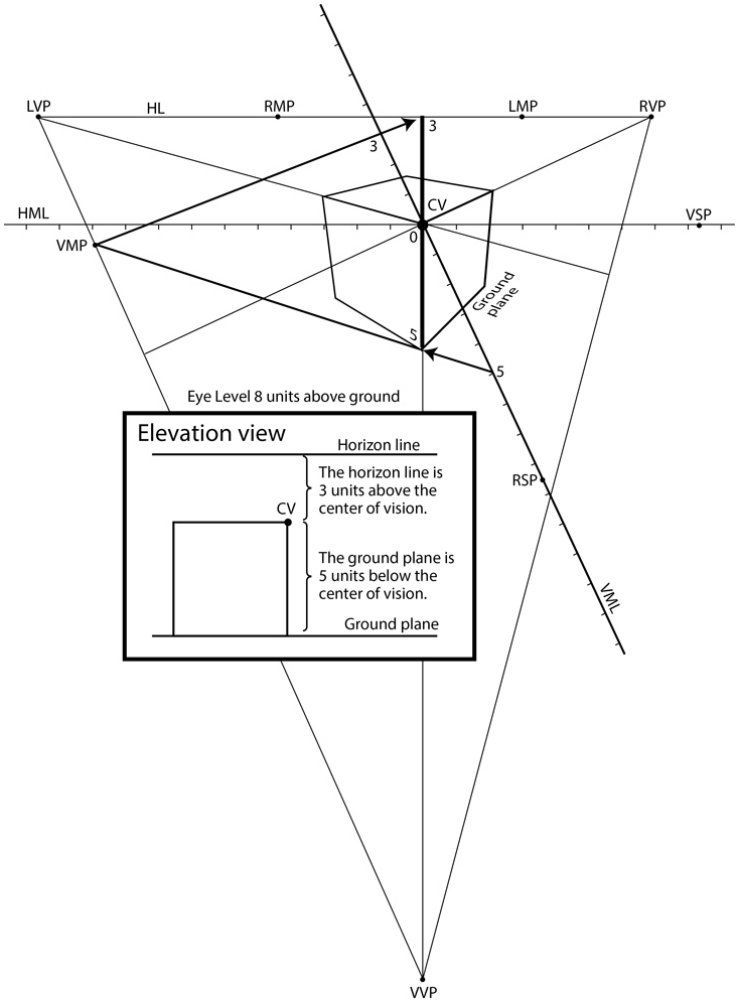


Figure 17.31 In this example, there are 5 units between the ground and the center of vision. There are 3 units between the center of vision and the horizon line. The eye level is 8 units above ground. **Return to text.**⏎

chapter 17
Three-Point Angles

DOI: 10.4324/9781003488101-25

233. Now that the basics of three-point perspective have been covered (as unlikely as it may seem—yes, that was only the basics), vanishing points can be found, and objects can be measured. But, using this knowledge, all objects would be parallel with each other. To draw objects at different angles requires different vanishing points. The following explains how to find them.

Left, Right, and Vertical Axes

An object can turn in three directions: along a vertical axis, a right axis, or a left axis. This coordinates with the vertical, right and left vanishing points. The Cartesian coordinate system of *x*-, *y*-, and *z*-axes can be confusing when working with three vanishing points, so the terms left, right, and vertical will be used in their stead (Figure 17.1). These angles will be tackled one at a time.

Vertical Axis

As an object turns on a vertical axis, the left and right vanishing points change position. In one- and two-point perspective, the station point is used to find new vanishing points. Three-point perspective is different: the station point cannot be used. A different point is needed, a point of true angles, 90° from the left and right vanishing points. From this point, new left and right vanishing points can be found. This point is referred to as a vertical axis point (VAP). It is located on the vertical reference line, 90° from the right and left vanishing points. Use a triangle to draw a 90° corner along the vertical reference line. Make sure the legs of the triangle connect to the left and right vanishing points. To establish new left and right vanishing points, use this point as a station point when drawing in two-point perspective (Figure 17.2).

Vanishing Points

Any angle drawn from the vertical axis point creates a vanishing point that draws that same angle in perspective. For example, to rotate a box 20° clockwise, draw a true 20° angle at the vertical axis point and project that angle to the horizon line (Figure 17.3).

Measuring Points

New measuring points are needed for the new vanishing points. Measure the distance from the new vanishing point to the vertical axis point, and then project that distance to the horizon line (Figure 17.4). Measure width using the same procedures as in two-point perspective (Figure 17.5).

One-Point Objects

If an object continues to turn along a vertical axis, eventually one side will be parallel the picture plane (Figure 17.6).

This is a one-point object viewed in three-point perspective. Lines parallel to the picture plane have no vanishing point. Vertical lines still connect to the vertical vanishing point. Lines representing depth connect to the vertical reference point (Figure 17.7).

Measuring Width

Width is not foreshortened. Measure these dimensions along the horizontal measuring line as if drawing in one-point perspective (Figure 17.8).

Measuring Height

Measure vertical dimensions along the vertical reference line. The vertical reference line is on the same plane as the measuring line (Figure 17.9).

Measuring Depth

The vertical reference point serves as the vanishing point. To find the measuring point, use a compass. Measure the distance from the vertical reference point to the vertical axis point and transfer that distance to the horizon line. The measuring point can be placed on the right or left side.

With the measuring point in place, measure using the technique in one-point perspective (Figure 17.10).

Right Axis

In this next example, the box is rotating along an axis that aligns with the right vanishing point. This box tilts backward to the left or forward to the right. All lines parallel to the axis of rotation still connect to the right vanishing point. As the object rotates, the left and vertical vanishing points change position, and the right vanishing point remains in its place. To rotate an object along a right axis, new left and vertical vanishing points are needed.

Right Axis Point

To move the location of the left and vertical vanishing point, a right axis point (RAP) is needed. The right axis point is the point of true angles between the left and vertical vanishing point. Use a triangle and align its legs to the left and vertical vanishing points. Place the 90° corner of the triangle on the right reference line. This marks the location of the right axis point (Figure 17.11).

Vanishing Points

A 90° angle placed at the right axis point creates two vanishing points that draw 90° angles in perspective. The new vanishing points are placed along the line that connects the left and the vertical vanishing points. To accommodate the new vanishing points, this line may be extended to whatever length necessary (Figure 17.12).

Measuring Points

The measuring points are placed on the same line as the vanishing points. Measure the distance from the vanishing point to the right axis point. The distance from the vanishing point to the measuring point will be the same length (Figure 17.13). Use a compass or ruler to transfer the distance.

Measuring Line

The measuring line must be parallel with the line the measuring points are on. Since the measuring points are on an angled line, the measuring line must be at the same angle (Figure 17.14).

The measuring procedure is the same—except it is sideways. Confirm that the object being measured is on the same plane as the measuring line. Determining this can sometimes be challenging; it takes some practice.

Complete the Box

Connect lines to the new vanishing points. Lines parallel to the ground plane (parallel to the axis of rotation) connect to the right vanishing point (Figure 17.15).

Left Axis

A left axis rotation follows the same procedure as a right axis rotation. There is a new axis point: the left axis point (LAP). It is located on the left reference line, 90° from the right and vertical vanishing points (Figure 17.16). There are new measuring points (Figure 17.17). There is a new measuring line, parallel to the line the measuring points are on (Figure 17.18). Connect lines to vanishing points to complete the box (Figure 17.19).

Cartesian Coordinate System

The Cartesian coordinate system is a graph that allows a point in space to be accurately plotted. In three-dimensional Cartesian

space this is accomplished using three axes labeled *x, y*, and *z*. There are variations to these designations, but traditionally *x* and *y* are placed on a horizontal plane, with *y* representing width and *x* representing depth. Height is represented by *z*. This is the right-handed Cartesian coordinate system, and it is the system used in this book.

One-Point Angles

A one-point perspective box, seen in a three-point view, can tilt forward or backward (rotate along the *y*-axis), or tilt to the left or right (rotate along the *x*-axis) (Figure 17.20). These angles are approached differently than the others encountered thus far, so it is worthwhile to address each of them.

x-Axis

The axis designated *x* rotates around a line connected to the vertical reference point. The object tilts to the left or right along this axis—this creates new vanishing points. To locate these new vanishing points, a point of true angles for *x* is needed.

The point of true angles for *x* is located along the vertical reference line. Measure the distance from the vertical vanishing point to the vertical station point. Transfer that distance to the vertical reference line (Figure 17.21). This is the point of true angles, the *x*-axis point (XAP).

252. 253. Any 90° angle drawn from the *x*-axis point will create two vanishing points 90° apart. These vanishing points are aligned horizontally with the vertical vanishing point (Figure 17.22). Measuring points are also aligned horizontally with the vertical vanishing point and are found by measuring the distance from the vanishing point to the *x*-axis point (Figure 17.23). Connect lines to vanishing points to complete the box (Figure 17.24).

y-Axis

255. The final rotation is along a horizontal axis, the *y* coordinate. The box tips forward or backward.

The point of true angles for the *y*-axis is the vertical station point (Figure 17.25, top).

256. 257. The vanishing points and measuring points are placed on the vertical reference line (Figure 17.25, bottom).

Measure the height and depth using a measuring line that is parallel to the vertical reference line (Figure 17.26, top).

Connect to vanishing points to complete the left side of the box (Figure 17.26, bottom). Complete the box using horizontal lines for the thickness (Figure 17.27).

Three-Point Diagrams

At this point, the focus will change to a previous topic: creating a three-point diagram. Not generically, as before, but creating a diagram from a specific viewpoint. This could not have been done earlier. To create a diagram from a specific viewpoint, it is necessary to understand how axes points work.

Angle of Sight

First, consider the center of vision. In three-point perspective the viewer is looking up or down, but at what angle? The horizon line is at the eye level, and the vertical vanishing point is 90° from the horizon line. The center of vision is somewhere between them. To place the center of vision at a specific location, so the viewer is looking at a precise angle, use the vertical station point. There is 90° between the vertical vanishing point and the vertical reference point, 90° between looking straight down and looking straight ahead. If the viewer is looking at a specific angle, place that angle at the vertical station point. For example, if the viewer to looking down 20°, then draw a 20° angle down from the vertical station point (Figure 17.28).

Angle of Object

The next step is to orient the angle of the object to the picture plane. The vertical axis point works the same as the station point in two-point perspective. The vertical axis point

determines the object's angle to the picture plane. For example, if the object should be turned 60°/30° to the picture plane, draw those angles at the vertical axis point (Figure 17.29, right).

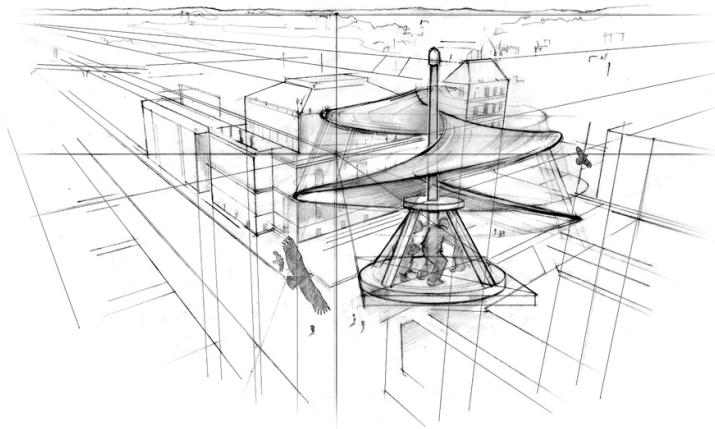
First Steps

If a specific angle is desired for a three-point diagram, it is best to start with the vertical station point (Figure 17.30). Work out the diagram from there, establishing the center of vision, then using the vertical axis point to define the angle of the object to the picture plane.

Eye Level

The viewer's eye level depends on the placement of the ground plane.

The horizontal measuring line is placed at the center of vision, which can be—but is not necessarily—on the ground. The ground plane is determined by the drawing. Decide where the ground is, then measure the distance from the ground to the horizon line to determine the eye level (Figure 17.31).



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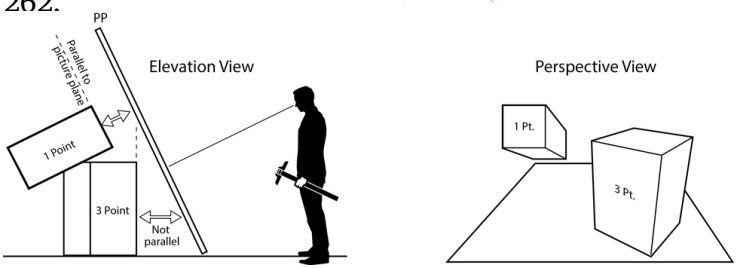
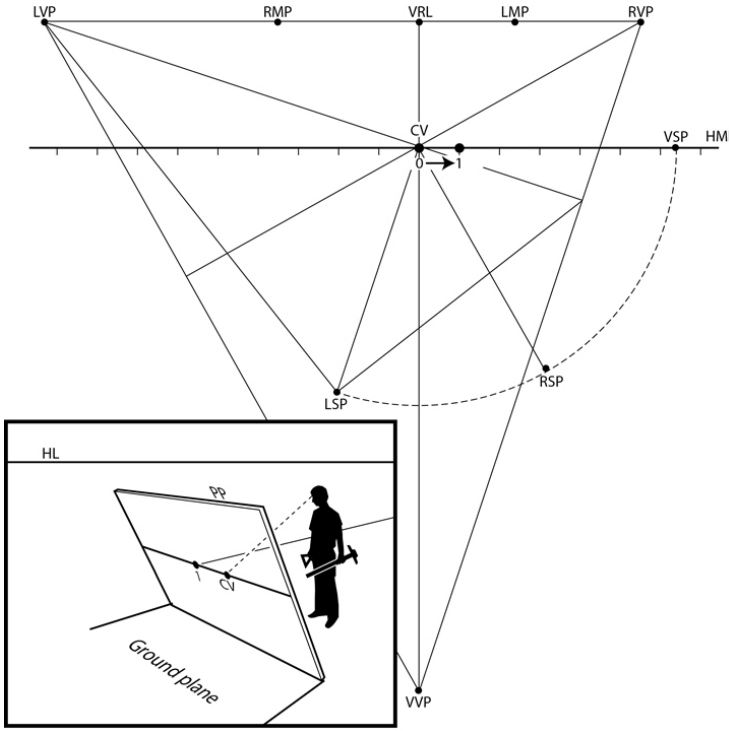


Figure 18.1 When combining a one-point object in a three-point view, the front of the one-point box is parallel to the picture plane. In one-point perspective, horizontal and vertical dimensions are parallel to the picture plane. In three-point perspective, all dimensions are foreshortened. **Return to text.**⏎ 264.



A view from behind the picture plane showing one unit to the right of the center of vision.

Figure 18.2 Measure 1 unit to the right of the center of vision.

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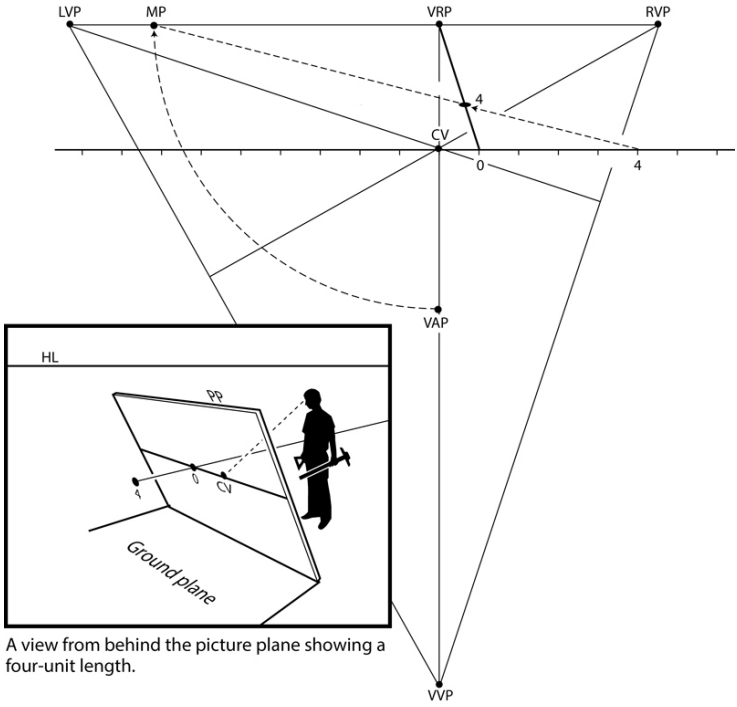
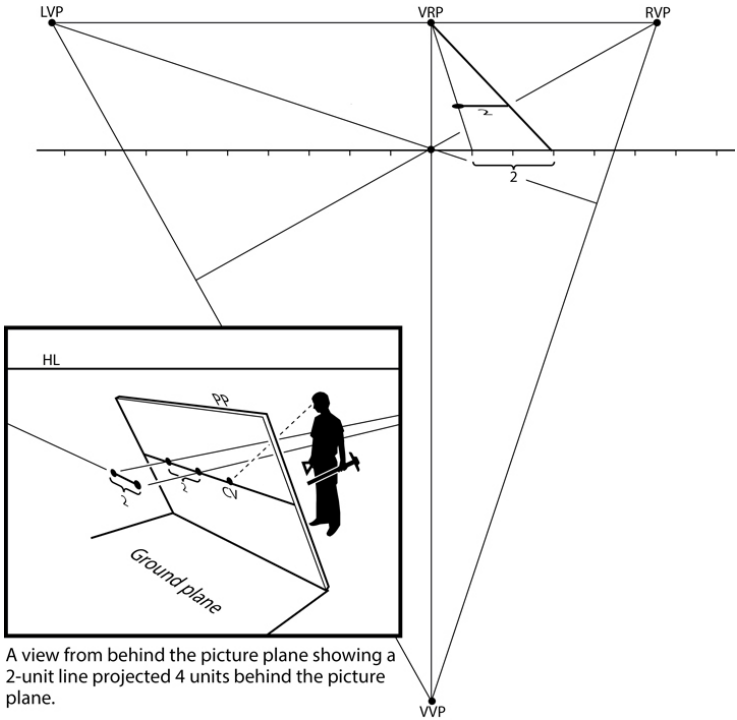


A view from behind the picture plane showing a four-unit length.

Figure 18.3 Measure 4 units behind the measuring line. An angle 90° to the measuring line connects to the vertical reference point. A measuring point for the vertical reference point is needed. **Return to text.** 265. 266.



A view from behind the picture plane showing a 2-unit line projected 4 units behind the picture plane.

Figure 18.4 Horizontal dimensions are parallel to the picture plane. Measure 2 units along the horizontal measuring line. Project the 2 units to the desired location. **Return to text.**⏎

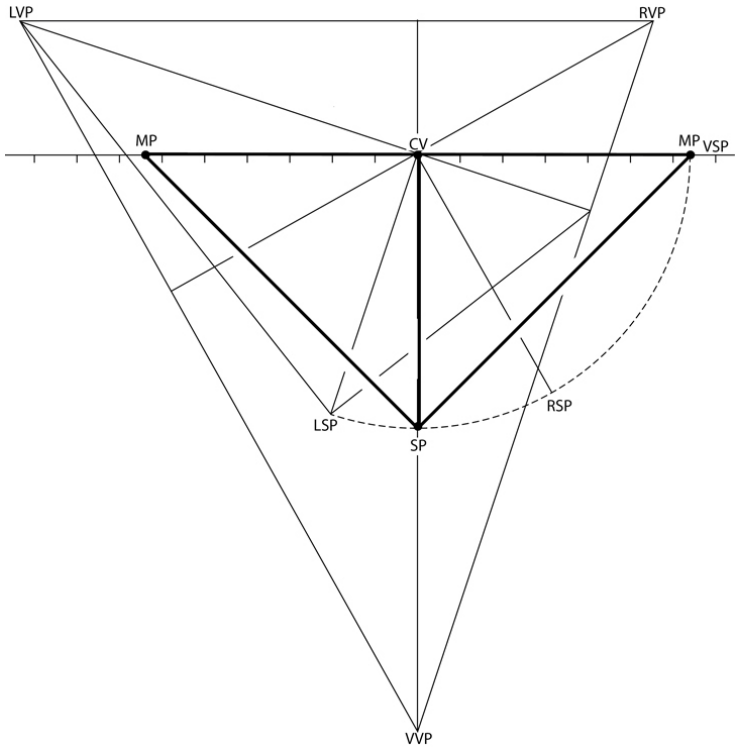


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Figure 18.5 A one-point diagram can be superimposed on a three-point diagram if both diagrams use the same center of vision and the distance from the station point to the picture plane remains constant. **Return to text.**⏎ 268.

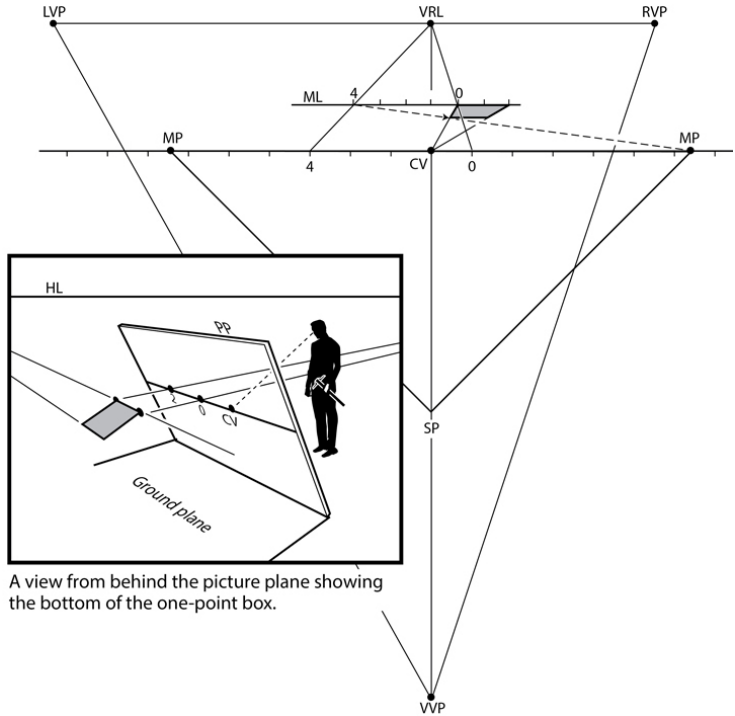


Figure 18.6 Lines drawn to the center of vision are 90° from the picture plane (but at an angle to the ground plane). Measure depth as measured in one-point perspective. Proper placement of the measuring line is vital. **Return to text.**⏎ 269.

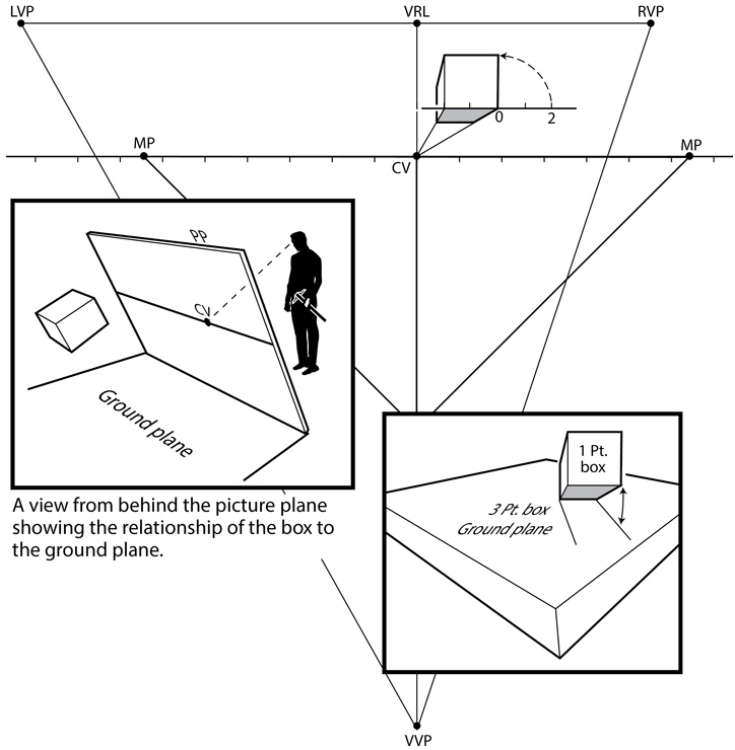


Figure 18.7 Finish the box by rotating the horizontal measuring line 180° to establish the height. **Return to text.**⏎ 270.

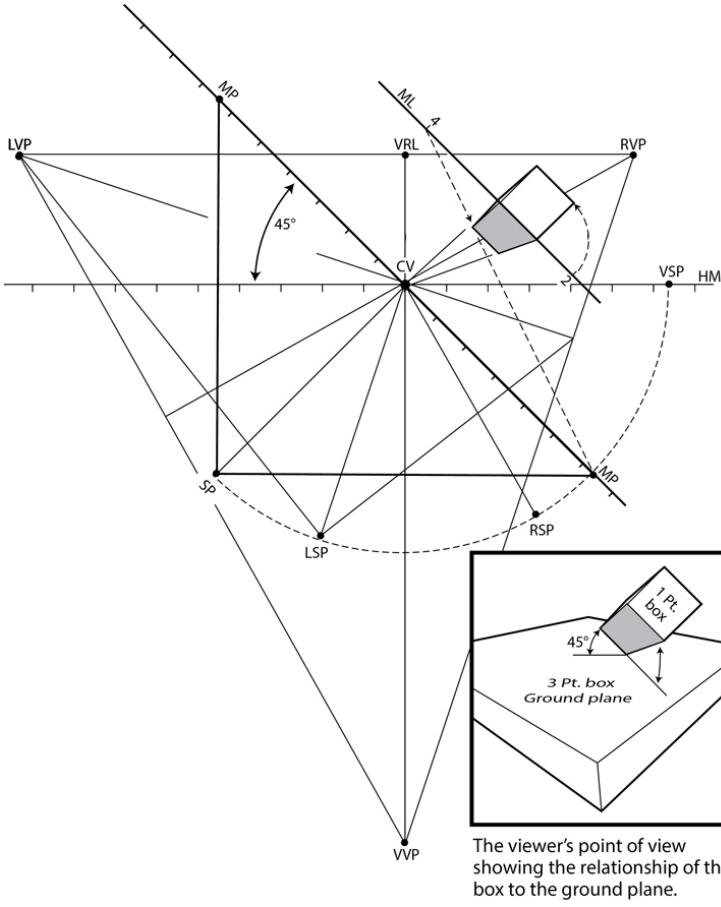


Figure 18.8 The box can be rotated along the *y*-axis by rotating the diagram the desired angle. **Return to text.**⏎

chapter 18
Combining One- and Three-Point Perspective

DOI: 10.4324/9781003488101-26

263. Imagine the following scenario: a person is on a balcony looking down at a photographer. The photographer is taking their picture. The scene below is in three-point perspective—except for the camera. The camera is facing the person on the balcony, so the camera is in one-point perspective. There are endless scenarios where a one-point object can be envisioned in a three-point scene. This chapter combines a three-point view with a one-point object (Figure 18.1).

One-Point Vanishing Point

Objects in one-point perspective have vertical and horizontal dimensions parallel to the picture plane, and foreshortened lines connect to the center of vision.

The Placement

To illustrate this, draw a one-point box, 2 units wide, 2 units high, and 4 units deep. It is 1 unit to the right of the center of vision and 4 units behind the picture plane. First, measure 1 unit to the right of the center of vision (Figure 18.2). Then, measure 4 units behind the picture plane (Figure 18.3). Make this point the bottom left corner of the box.

Width

The box is 2 units wide. Measure the width along the measuring line and project the distance backward, using the vertical reference point (Figure 18.4).

Superimposing Diagrams

Now the width and location of the one-point box have been established. All of this was done using the three-point diagram. But to draw the one-point box, and to measure its depth, requires a one-point diagram. A one-point diagram needs to be superimposed on the three-point diagram. Combining a one-point diagram and three-point diagram is not difficult. There are, however, two important rules to remember.

First, a person can only look in one place at any given time, so there can be only one center of vision. The center of vision in the one-point diagram must be in the same place as the center of vision in the three-point diagram. Second, a person can be in only one place at a time; thus the distance from the viewer to the picture plane must remain constant. The distance from the center of vision to the station point must be the same in the one-point diagram as it is in the three-point diagram. Keep these two important rules in mind when superimposing multiple perspective diagrams (Figure 18.5).

Depth

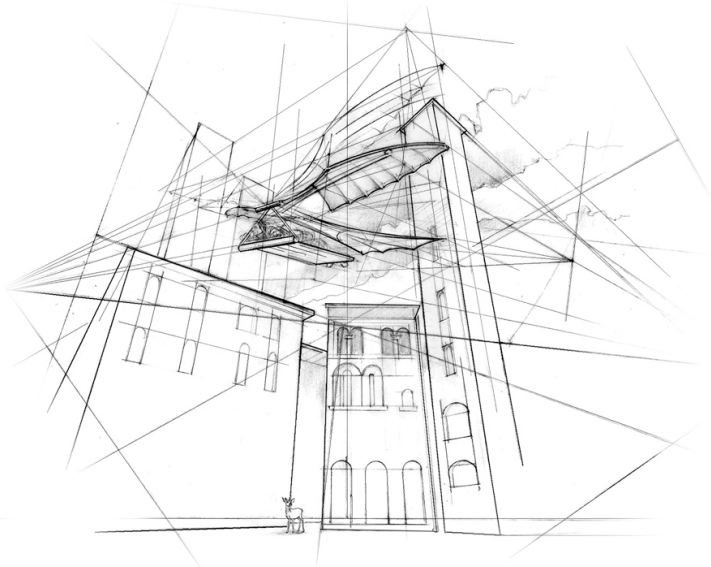
Move the measuring line so it is on the same plane (touching) the line being measured. Measure the depth using one-point perspective guidelines (Figure 18.6).

Height

Turn the measuring line vertically to measure height (Figure 18.7). The height is parallel to the picture plane and is not foreshortened. Measuring points are not required to measure height and width in one-point perspective.

Rotating a One-Point Object

The one-point diagram can be rotated to any angle using the center of vision as an axis point. The angles are true angles. For example, if the one-point diagram is rotated 45° clockwise, the box being drawn will be rotated a true 45° clockwise (Figure 18.8). Remember, there can be only one center of vision, and the distance from the station point to the picture plane remains constant.



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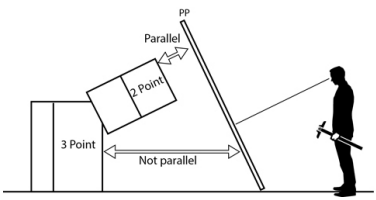


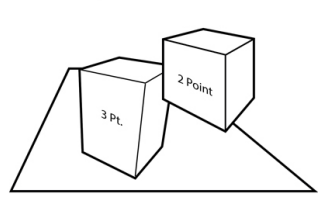
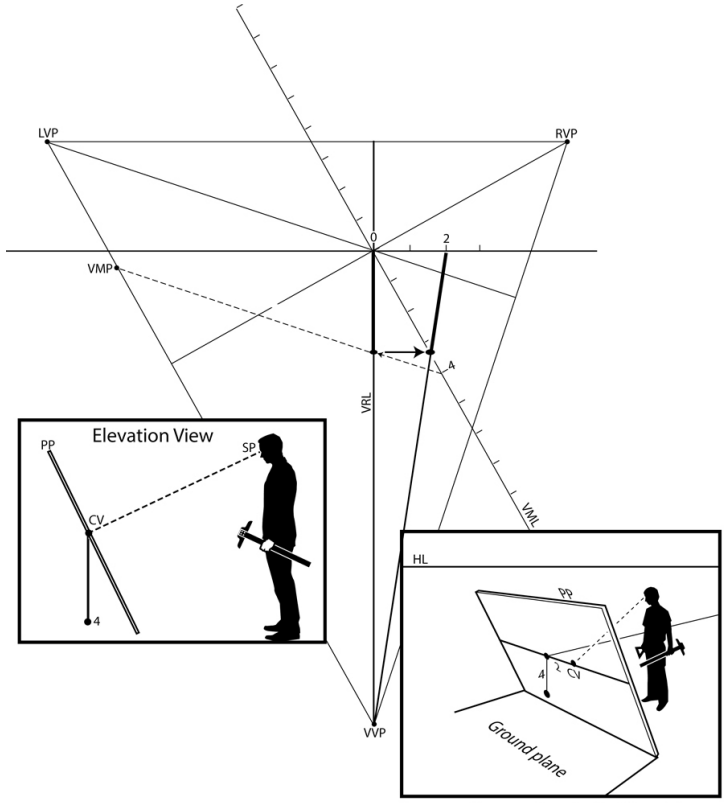


Figure 19.1 A two-point object in a three-point view. Return to



A perspective view from behind the picture plane showing a three units to the right and three units down.

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Figure 19.2 The box is 2 units to the right and 4 units below the center of vision. Return to text.⏎ 273. 274.

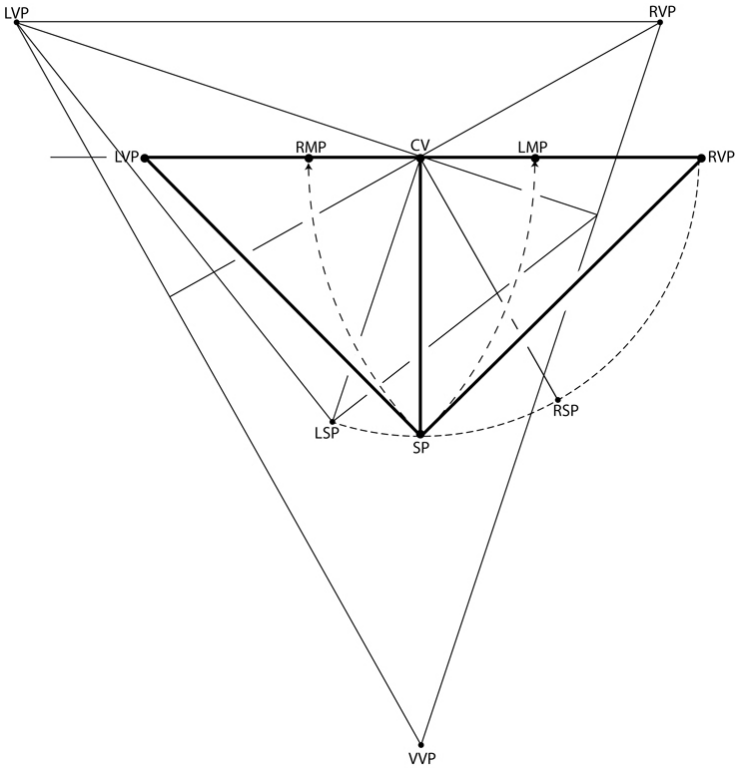


Figure 19.3 A two-point diagram superimposed on a three-point diagram. The left and right vanishing points are set up at 45°. **Return to text.**⏎ 275.

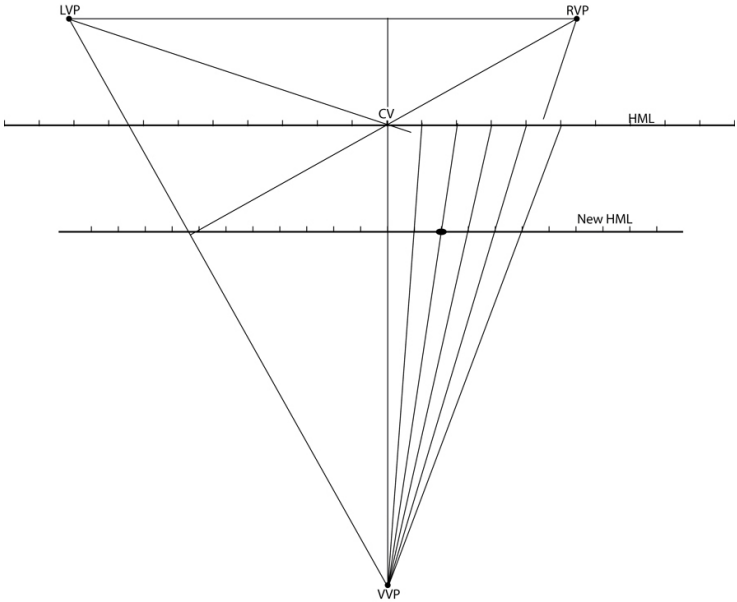
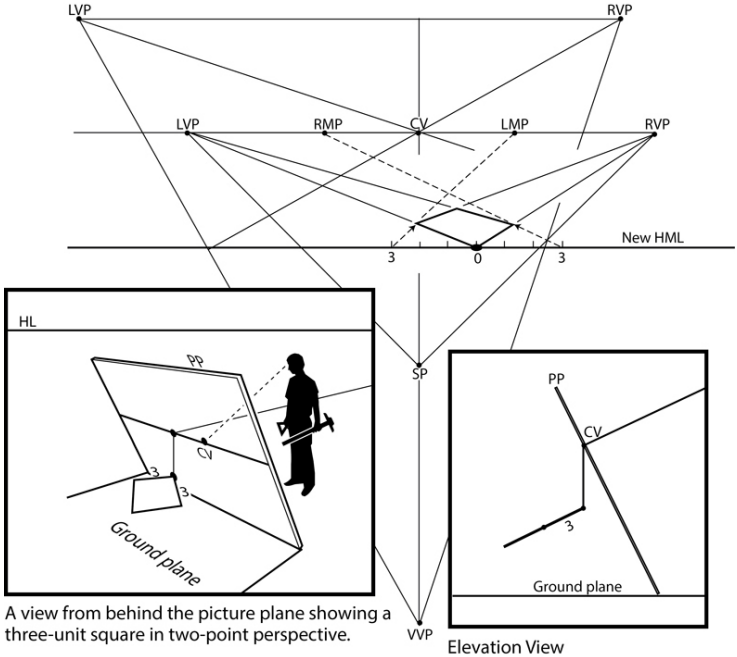


Figure 19.4 Move the measuring line down 4 units, so it is on the same plane as the line being measured. **Return to text.**



A view from behind the picture plane showing a three-unit square in two-point perspective.

Elevation View

Figure 19.5 Measuring horizontal dimensions follows the same procedures as outlined in two-point perspective. **Return to**

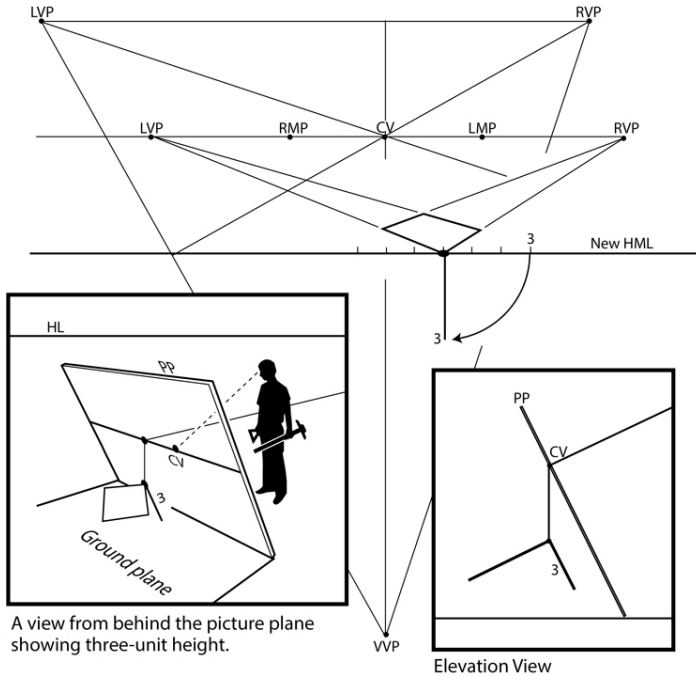


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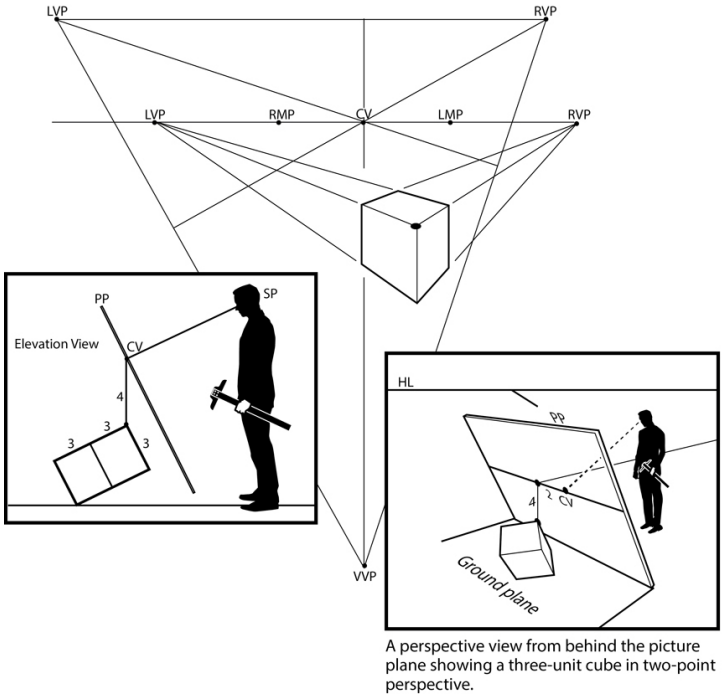
Figure 19.6 Height is parallel to the picture plane and not foreshortened. Turn the measuring line vertically. **Return to text.⏎** 278.



A perspective view from behind the picture plane showing a three-unit cube in two-point perspective.

Figure 19.7 Connect lines to vanishing points to finish the box.

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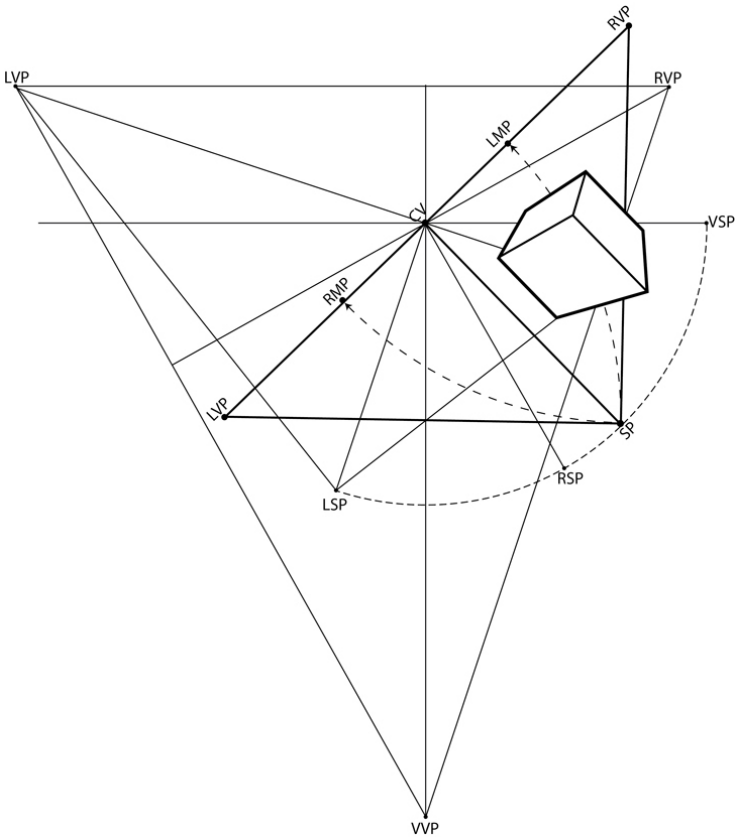

Figure 19.8 To rotate the object being drawn, rotate the two-point diagram. **Return to text.**⏎

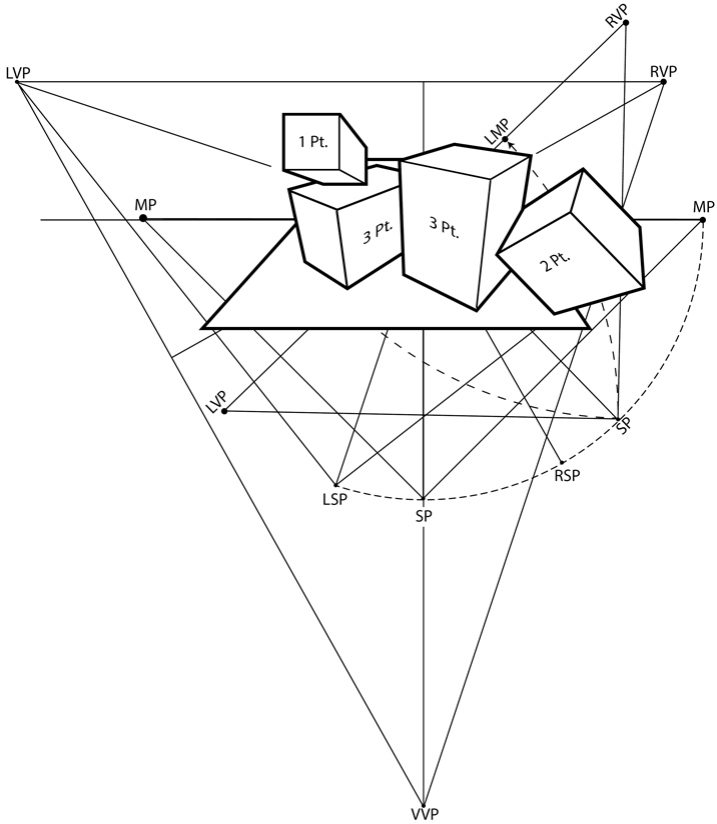

Figure 19.9 Combining one-, two-, and three-point perspective.
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chapter 19
Combining Two- and Three-Point Perspective

DOI: 10.4324/9781003488101-27

272. In two-point perspective, the vertical lines are parallel to the picture plane (Figure 19.1). The procedures to combine two-

point and three-point diagrams follow the same rules that apply to combining one-point and three-point diagrams. For this example, draw a 3-unit cube. This cube is located 2 units to the right of the center of vision and 4 units below the measuring line (Figure 19.2).

First, using the horizontal measuring line, measure 2 units to the right of the center of vision. Then, using the vertical measuring line, measure 4 units below the center of vision. This point represents the top front corner of the two-point box.

Superimposing Diagrams

The location of the two-point box was established using the three-point diagram (all these dimensions are in three-point perspective). To draw the two-point perspective box, a two-point perspective diagram is needed. When superimposing the two-point diagram, remember that there is only one center of vision (the two diagrams share the same center of vision), and the distance from the viewer to the picture plane remains constant.

Use the two-point diagram's station point to establish the left and right vanishing points. For example, if the cube is at a 45° angle to the picture plane, draw 45° angles from the station point (Figure 19.3).

Measuring

Take care that the measuring line and the object being measured are on the same plane. This can be challenging. In this example, the measuring line must be moved down to the level of the box. Use the vertical vanishing point to project the measuring line down 3 units, touching the line being measured (Figure 19.4).

276. Once the measuring line is in place, follow two-point perspective procedures to measure the width and depth (Figure 19.5).

277. Vertical dimensions are not foreshortened, so turn the

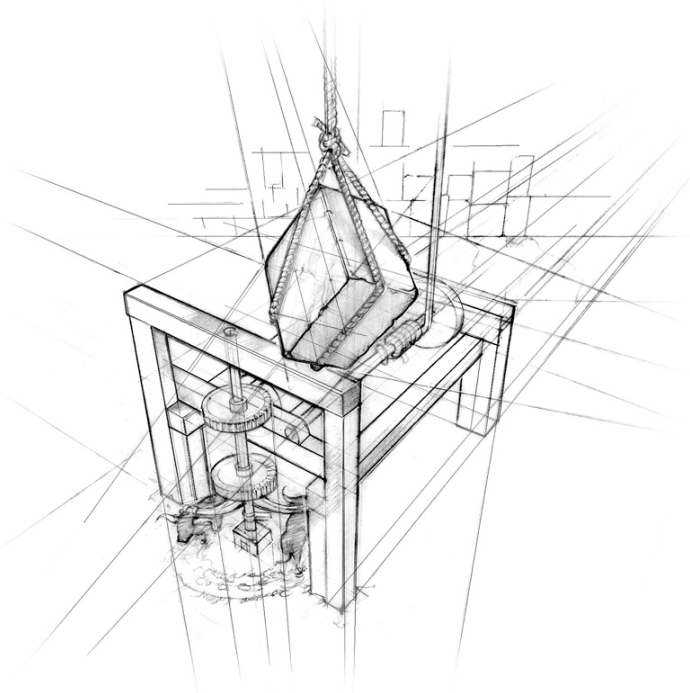
measuring line 90° to measure height (Figure 19.6).

Complete the Box

Connect foreshortened lines to the right and left vanishing points to complete the box (Figure 19.7).

279. The diagram can be rotated to any angle using the center of vision as an axis point (Figure 19.8).

280. Using these techniques, one-, two-, and three-point perspective can now be combined in the same illustration (Figure 19.9).



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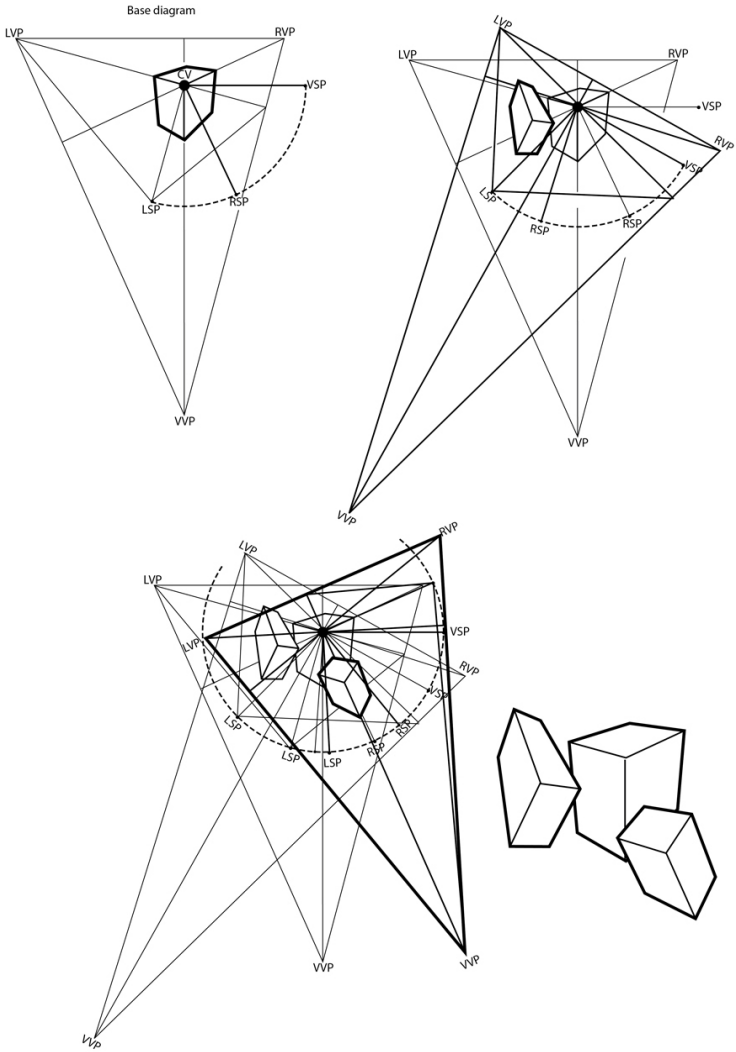


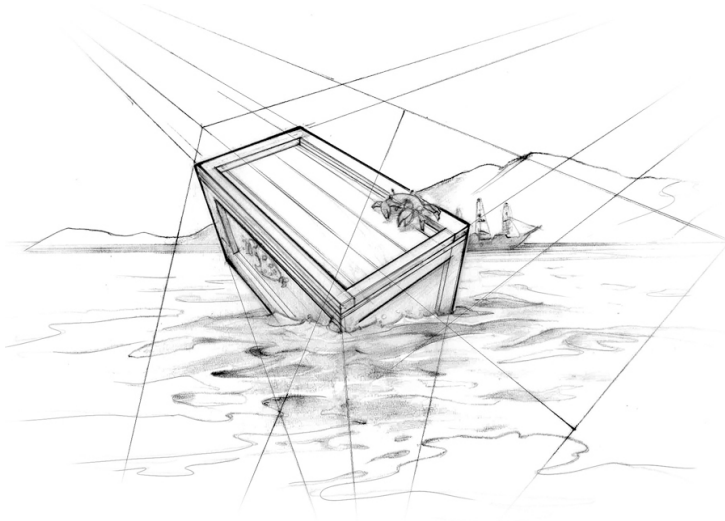
Figure 20.1 These superimposed diagrams share the same center of vision, and the distance from the picture plane to station point is consistent throughout. **Return to text.**⏎ 283.

chapter 20
Combining Three-Point

Perspective Diagrams

DOI: 10.4324/9781003488101-28

282. It may seem like every possible topic has been explored at this point. But there is more: superimposing multiple three-point diagrams (none of the objects share vanishing points, and no angles are parallel with the picture plane). To do this successfully, the two cardinal rules must be followed: there is only one center of vision, and the distance between the viewer and the picture plane must remain constant (Figure 20.1). In addition to the two cardinal rules, all superimposed three-point diagrams must maintain the angle relationships discussed in Chapter 16 (Figures 16.3–16.13).



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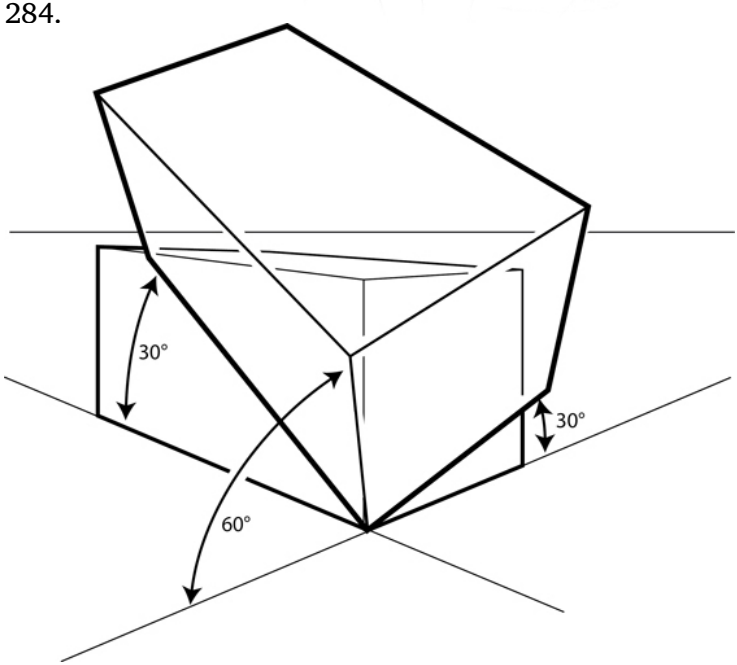


Figure 21.1 No dimensions are parallel to the ground plane.
Return to text.⏎ 286.

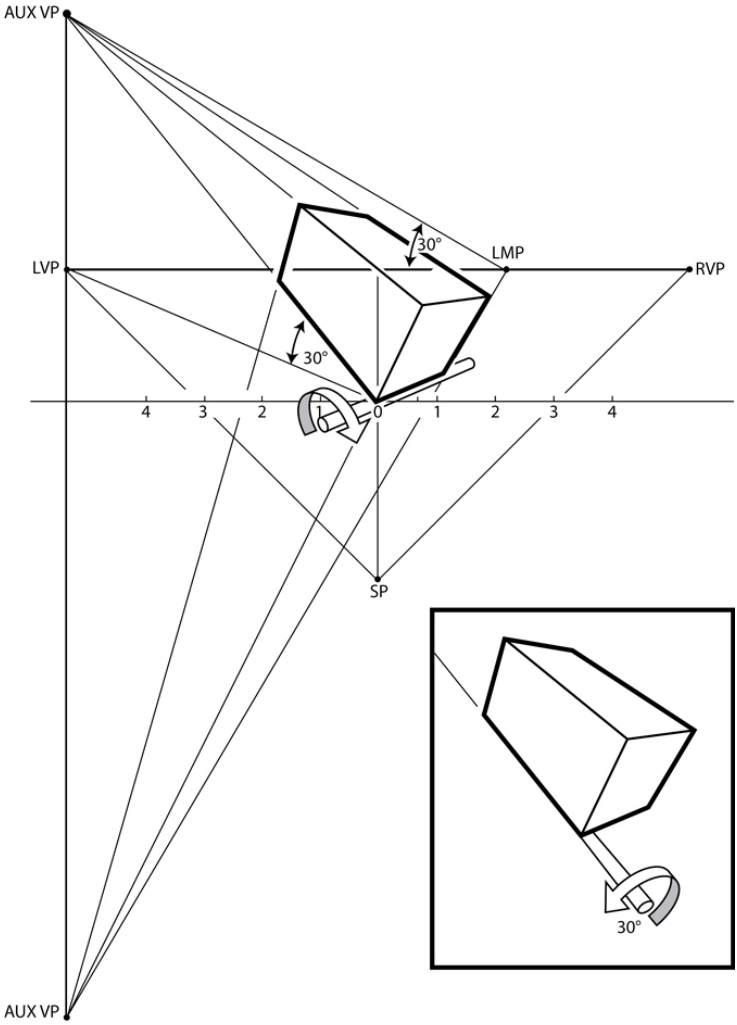


Figure 21.2 First, using a right axis point, lift the box 30° from the ground plane. Then, rotate the box 30° counterclockwise along an axis aligned to the upper auxiliary vanishing point. **Return to text.**⏎ 287.

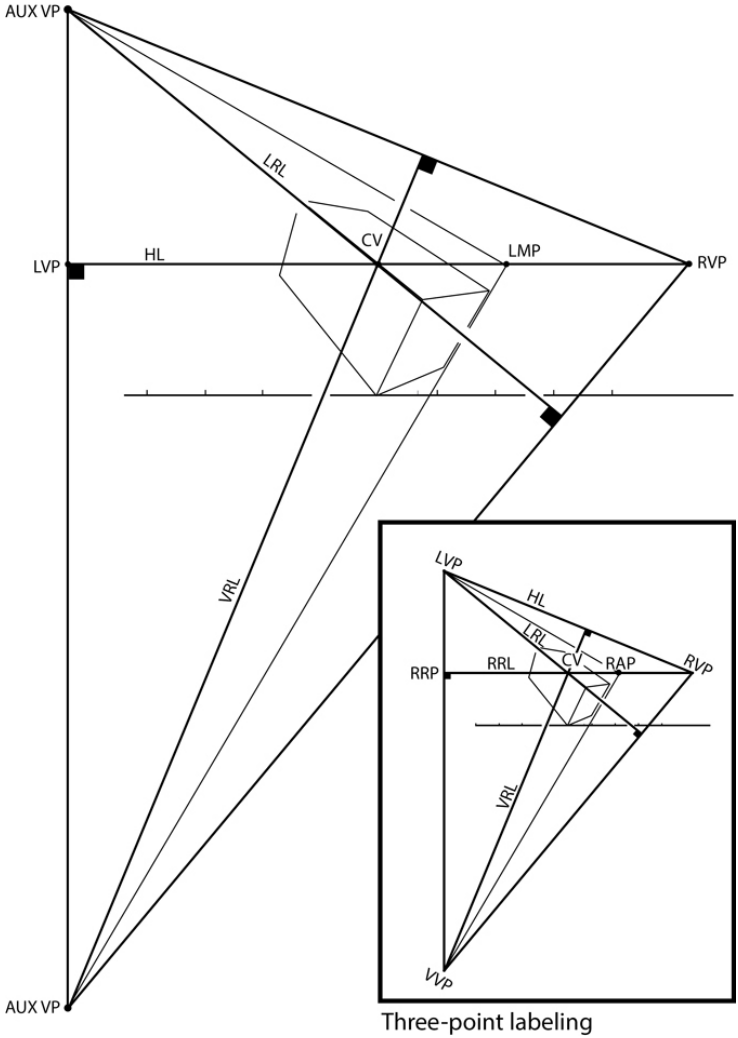


Figure 21.3 Create three reference lines, each intersecting the center of vision, and each at a right angle to the lines connecting the three vanishing points. This diagram is the same as a three-point diagram. The labels are different, but the geometry is the same. **Return to text.**⏎ 288.

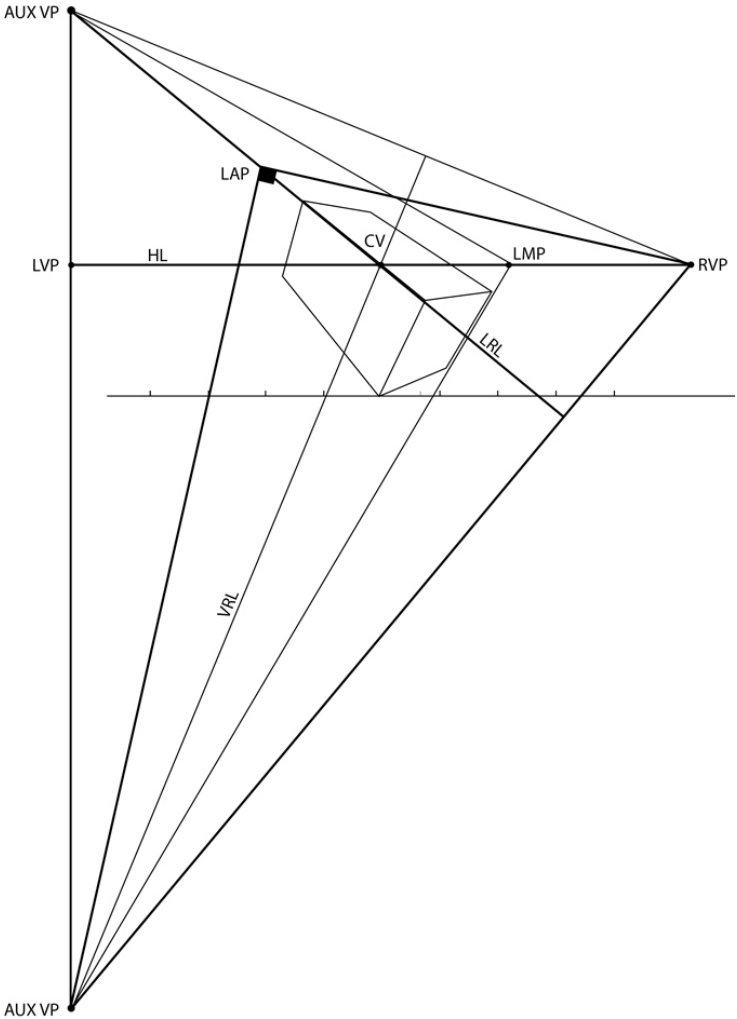


Figure 21.4 Establish the left axis point along the left reference line. **Return to text.**⏎ 289.

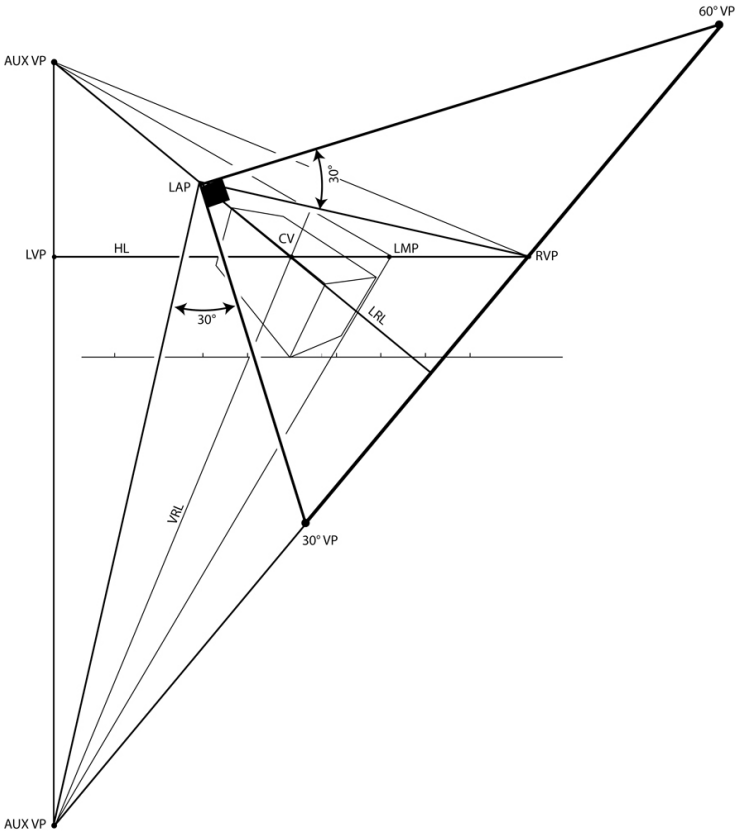


Figure 21.5 Plot two new vanishing points, keeping a 90° angle at the left axis point. **Return to text.**⏎

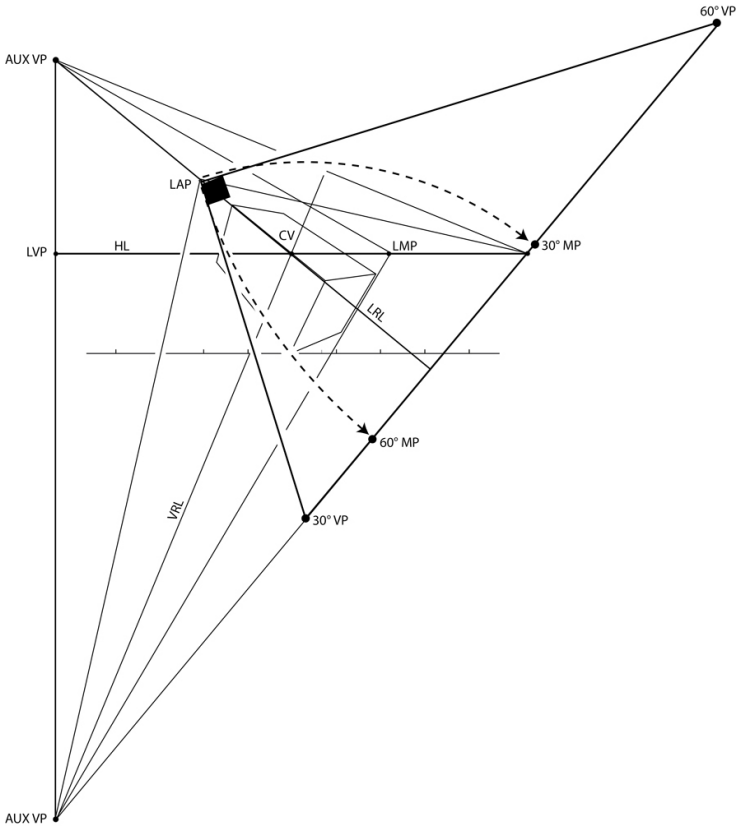


Figure 21.6 Plot measuring points for each of the new vanishing points. **Return to text.**⏎ 290.

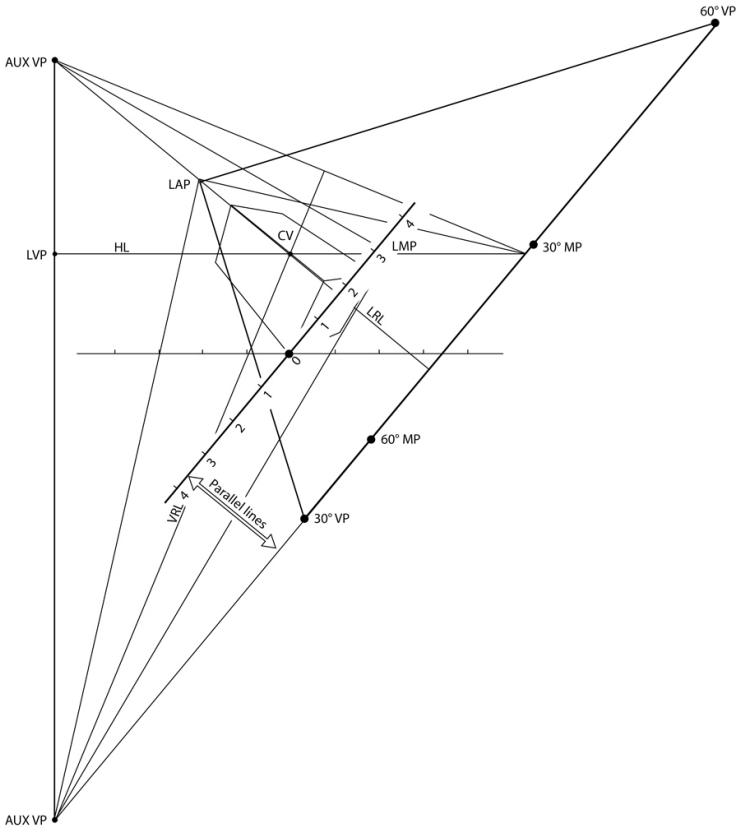


Figure 21.7 The measuring line must be parallel with the line the measuring points are on. Place the measuring line at the corner of the box to ensure it is on the same plane as the line being measured. **Return to text.**⏎ 291.

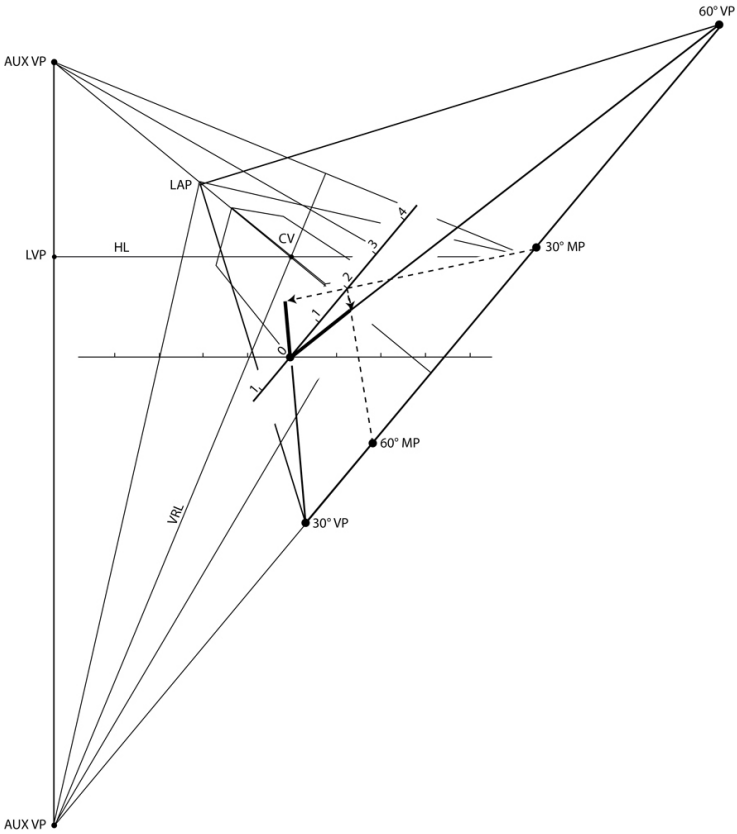


Figure 21.8 Measure the lines connecting to the 30˚ and 60˚ vanishing points. **Return to text.**⏎ 292.

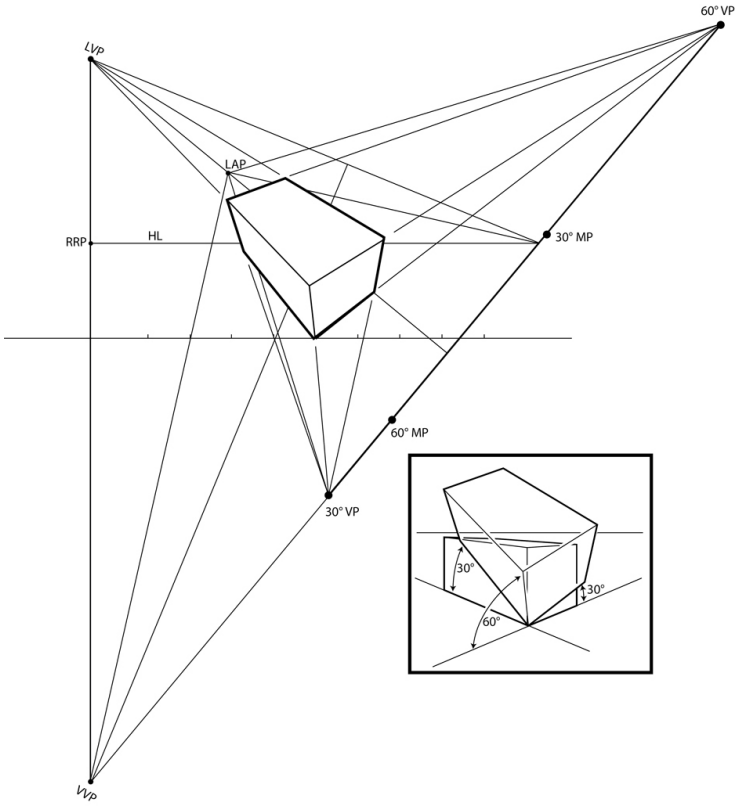


Figure 21.9 Connect lines to vanishing points to complete the box. This box is tilting up 30° from the ground plane and rotating 30° counterclockwise. **Return to text.**⏎ 293. 294.

chapter 21
Compound Inclines in Two-Point Perspective

DOI: 10.4324/9781003488101-29

285. It is time to revisit the world of two-point perspective,

where the viewer is looking parallel to the ground plane, and the center of vision is located on the horizon line. It is backtracking, but a good understanding of three-point perspective is needed to solve this next problem. In the next example, the box is tilted. Not tilted as drawn before, with one side parallel to the ground plane, and one side connecting to a vanishing point on the horizon line. This is a compound incline, a shape tilted so that no plane is parallel to the ground, and no lines connect to vanishing points on the horizon line. If this shape were touching the ground, it would do so at a corner. Imagine a pair of dice bouncing along a table. When they stop moving, the dice are in one- or two-point perspective. When moving, they are likely at an incline. It can be at a simple incline where one surface is parallel the ground plane or a compound incline where no surface is parallel to the ground plane.

The Compound Incline Box

For this example, draw a box. The back of the box is 30˚ above the ground plane, and the box then rotates counterclockwise 30˚ (Figure 21.1). This is best approached as a two-step process.

The Incline

The box is angled 30˚ from the ground plane. Follow the procedures outlined in Chapter 10. After drawing the incline (Figure 21.2), the box rotates counterclockwise 30˚. The axis of rotation is aligned with the upper auxiliary vanishing point (Figure 21.2, inset).

The Rotation

As the box rotates along this axis, the right and the lower auxiliary vanishing points change position. This is where the three-point procedures come into play. Create reference lines following the three-point perspective guidelines. (The diagram is the same as a three-point diagram. The only difference

between the two diagrams is the labeling; see Figure 21.3.)

Axis Point

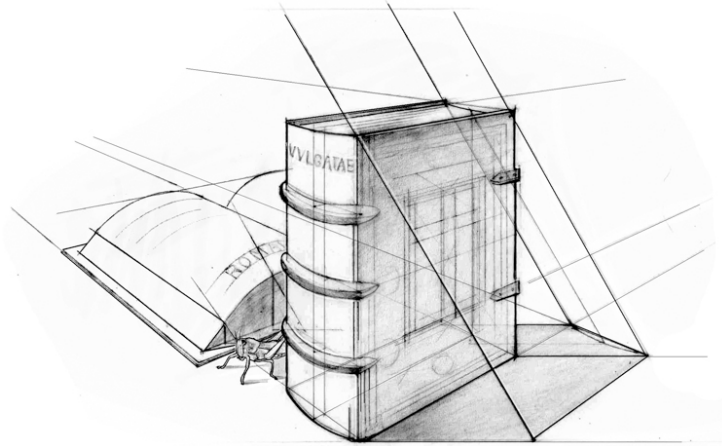
Since the right and vertical vanishing points change positions, the box rotates along a left axis. Thus, a left axis point is needed. This point is a true 90° between the right and the lower auxiliary vanishing points. Place the left axis point on the left reference line (Figure 21.4).

Complete the Box

Create new right and left vanishing points, rotated 30° counterclockwise (Figures 21.5). Plot corresponding measuring points (Figure 21.6). Be sure the measuring line is at the proper angle (Figure 21.7). Measure the box (Figure 21.8). Connect the corners to the vanishing points to complete the drawing (Figure 21.9). Review Chapter 18 for a detailed description of this procedure.

295. 296.

part nine
Shadows



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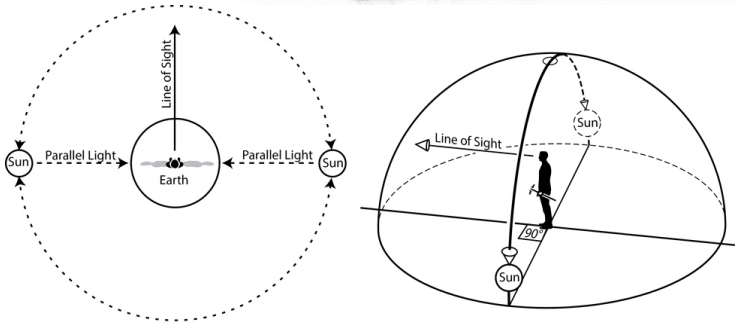

299. Plan view Light source 90° is from the line of sight

Figure 22.1 When the position of the sun is 90° from the line of sight, the shadows are parallel to the picture plane. **Return to text.**⏎ 300.

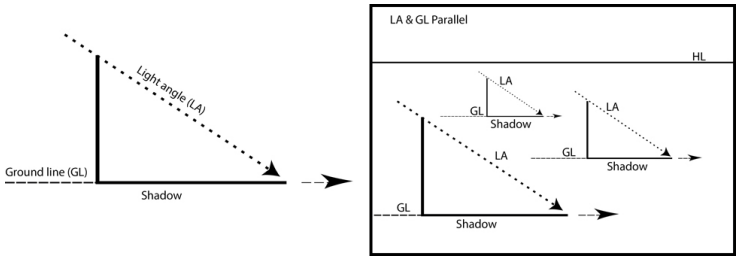

Figure 22.2 Rule One: Shadows of vertical lines follow the ground line angle. They are parallel to the horizon line. **Return to**

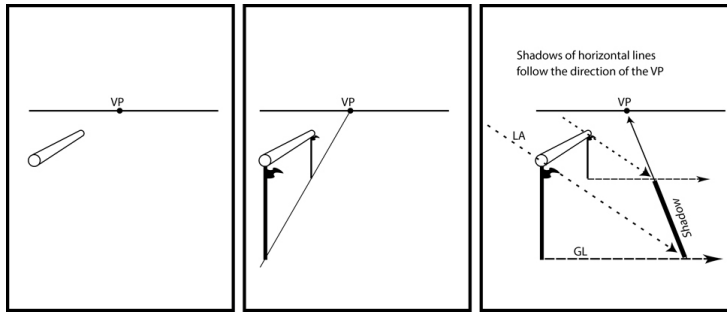

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Figure 22.3 Rule Two: Shadows of horizontal lines, parallel to the ground, connect to the same vanishing point as the line casting the shadow. Return to text.⏎ 301.

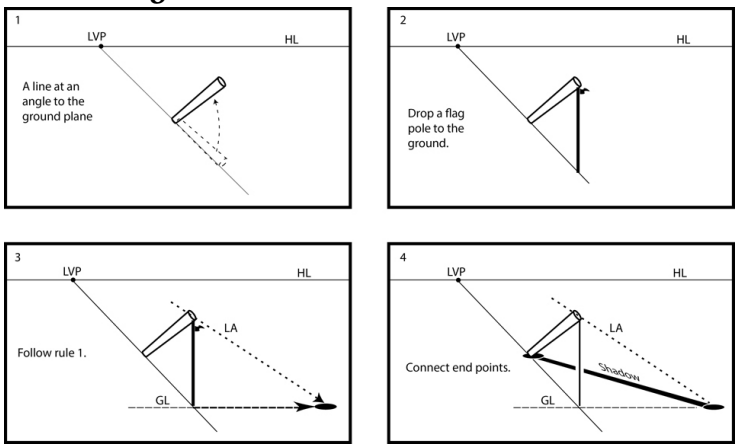


Figure 22.4 Rule Three: Plot the end points and connect the dots to find the shadow of angled lines. Return to text.⏎

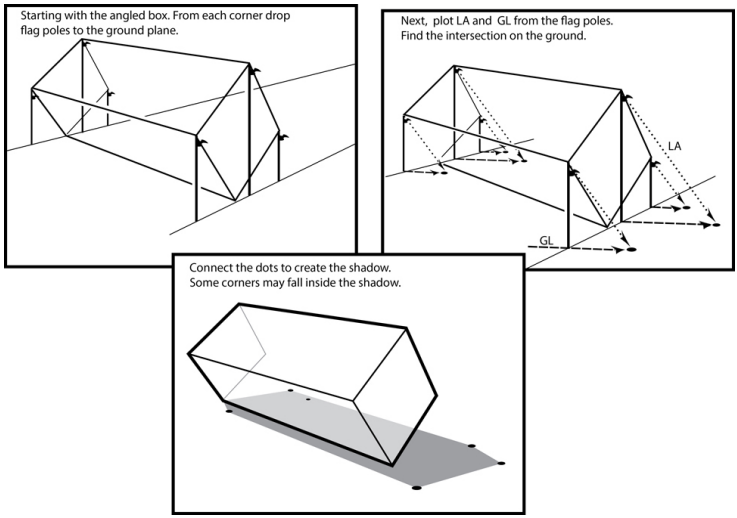


Figure 22.5 This example uses the flagpole technique to plot the shadow of a cuboid angled to the ground plane. **Return to text.**⏎ 302.

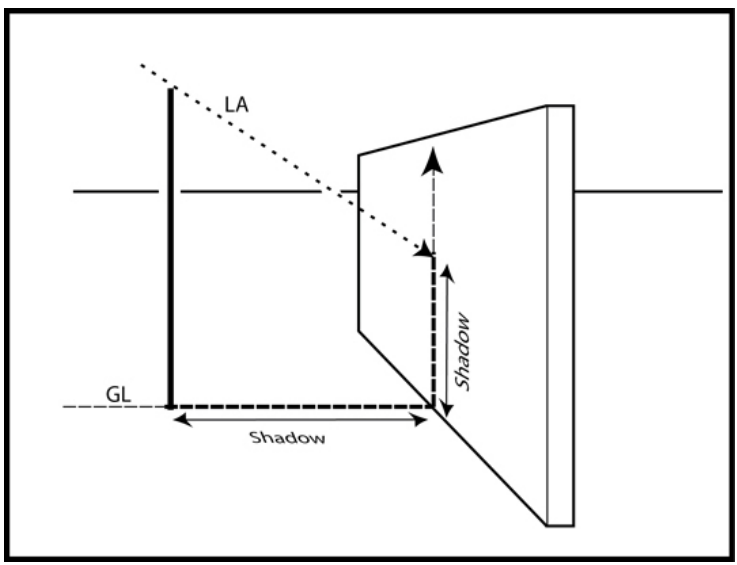
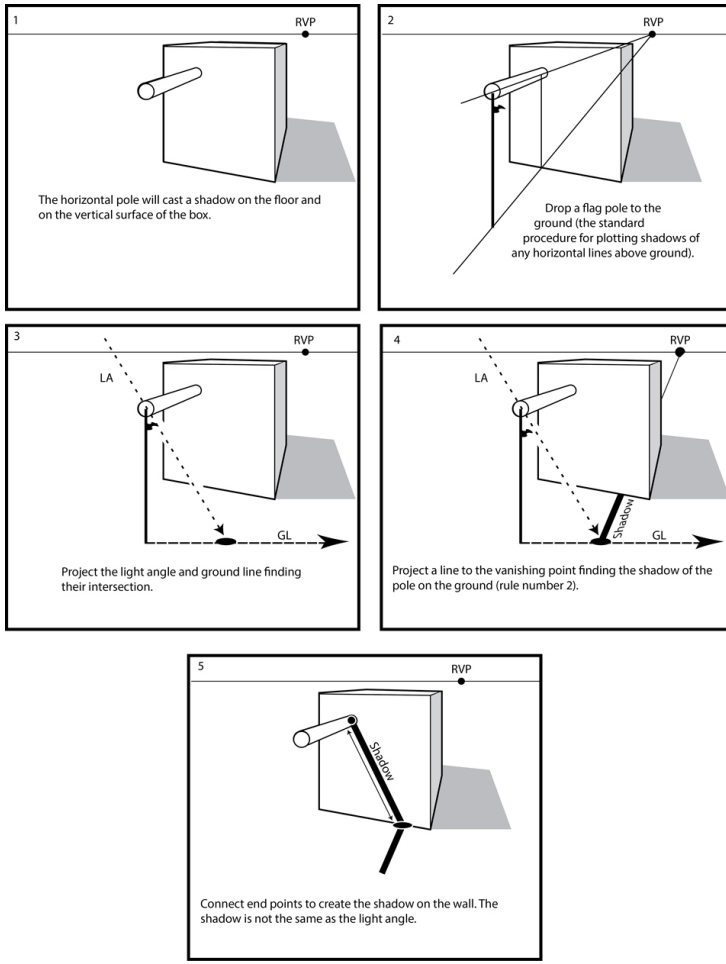


Figure 22.6 Rule Four: Vertical lines cast vertical shadows on vertical surfaces. If the pole and the wall are parallel, the pole and the shadow will also be parallel. **Return to text.**⏎



303.

Figure 22.7 The shadow cast from a horizontal line on a vertical surface is found by plotting the end points. **Return to text.**⏎

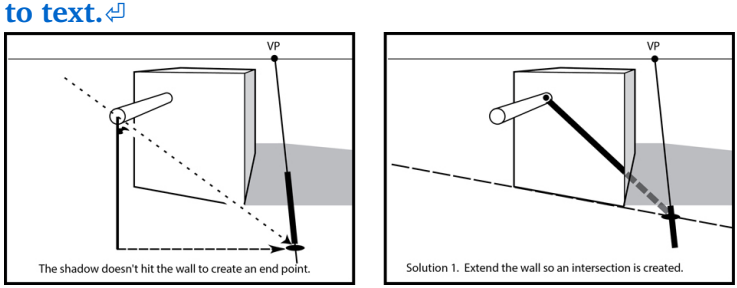


Figure 22.8 Solution 1. If the shadow does not intersect the box, the box can be extended. Draw a phantom wall long

enough to create an intersection. Return to text.⏎

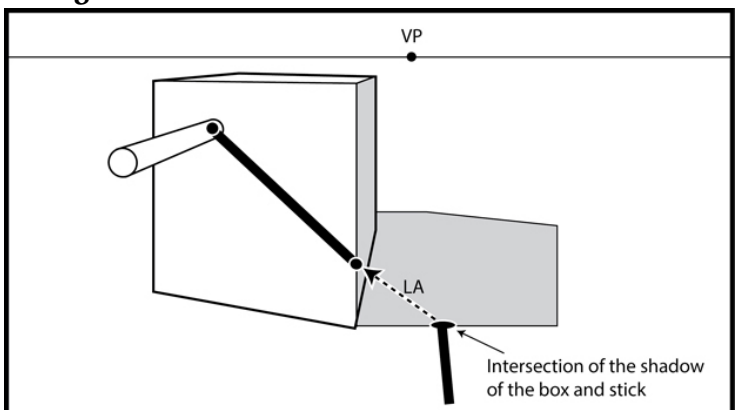


Figure 22.9 Solution 2. Draw the shadow of the box and pole. Find the intersection of the two shadows. Using the light angle, project the intersection of the shadows on the ground, to the side of the box, creating an end point. Return to text.⏎

306.

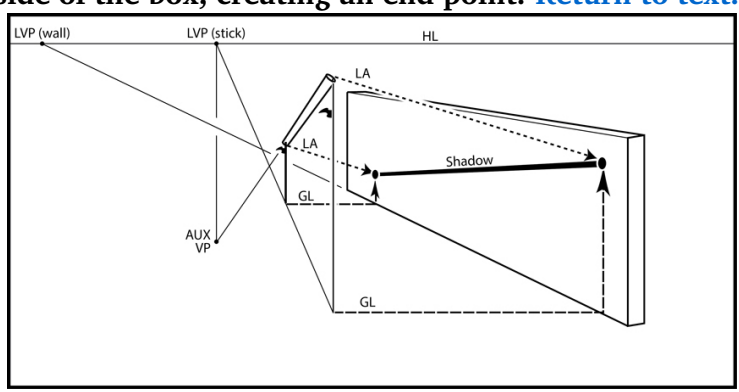
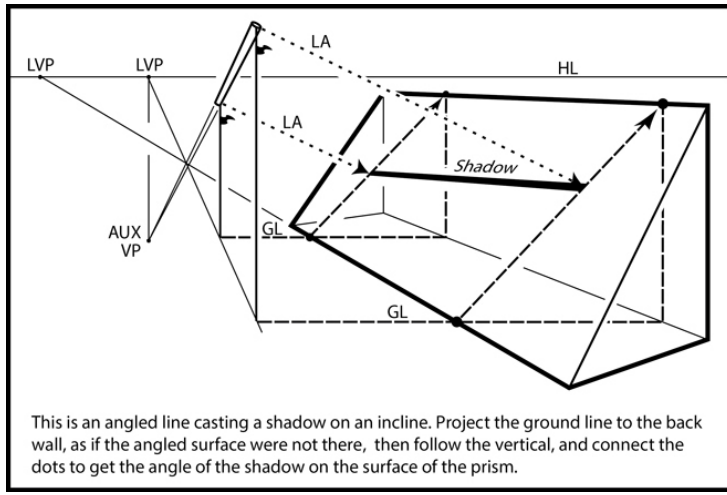


Figure 22.10 Rule Six: shadows of angled lines (this line is angled to both the ground and the wall) are found by plotting, and then connecting, the end points. Return to



text.⏎

Figure 22.11 Rule Seven: shadows on angled surfaces are found by plotting and then connecting the end points.
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chapter 22
Shadows

DOI: 10.4324/9781003488101-31

298. There are two types of light sources: natural and artificial. In the world of perspective, natural light emanates from the sun (including that which is reflected by the moon). Any other light source is considered artificial. Fire sources such as candles, and electrical sources such as light bulbs, are all considered artificial.

Shadow Components

Natural Light Shadows

Shadows from natural light can be placed into three categories: positive shadows, negative shadows, and parallel shadows. These categories are based on whether the light source is in front, behind, or to the side of the viewer.

Artificial Light

Shadows from artificial light sources are called converging shadows (sometimes the terms concentric or radiating shadows are used when discussing artificial light).

Ground Lines and Light Angles

Whether natural or artificial, all shadows are plotted using a ground line (GL) and a light angle (LA). A light angle is the angle of the light ray to the ground plane and is used to determine the length of the shadow. The ground line is a directional line parallel to the ground plane and is used to determine the angle of the shadow.

Shadow Rules

There are rules that describe the behavior of shadows. These rules may seem abstract at first, but with practice they become intuitive.

Shadows on Horizontal Surfaces

Shadows on horizontal surfaces follow these rules:

Rule One. Shadows of vertical lines follow the ground line angle.
Rule Two. Shadows of horizontal lines are parallel to the lines casting them.
Rule Three. Shadows of angled lines are found by plotting the line's end points.

Shadows on Vertical Surfaces

When a shadow falls on a vertical surface, these rules must be

followed:

Rule Four. Vertical lines cast vertical shadows.
Rule Five. Shadows of horizontal lines are found by plotting the line's end points.
Rule Six. Shadows of angled lines are found by plotting the line's end points.

Shadows on Angled Surfaces

On angled surfaces, there is one rule:

Rule Seven. Shadows on all angled surfaces are found by plotting the line's end points.

Parallel Shadows

Parallel shadows occur when the sun is directly to the right or left of the viewer, 90° from the line of sight. Imagine an arc overhead, beginning at the viewer's left and ending 180° to the viewer's right. If the sun is anywhere along this arc, the light angle and the shadows (the ground line) have no vanishing points; they are parallel to the picture plane (Figure 22.1). The ground line is drawn horizontally, directly to the left or right of the object.

If the sun is closer to the horizon line, the light angle is more oblique, and the shadows are longer. The higher the sun, the steeper the light angle and the shorter the shadows. The light angle determines the length of the shadow. The light angle—being parallel to the picture plane—is a true angle. For example, if the sun is 45° above the horizon line, all light angles are drawn at a true 45°. If the sun is directly overhead, all light angles are true verticals.

Following are examples of parallel shadows, each following one of the rules listed previously.

Rule One

Shadows of vertical lines follow the ground line angle. When

the light source is 90° from the line of sight, the ground line is drawn parallel to the picture plane, being a true horizontal line. If the light source is to the right, the shadows are to the left. If the light source is to the left, the shadows are to the right (Figure 22.2).

Rule Two

The shadows of horizontal lines are parallel to the lines casting them. The shadow, and the line casting the shadow, connect to the same vanishing point. To plot the shadow of a horizontal line, first project a vertical line to the ground. This creates a "flagpole." Draw the shadow of the flagpole using rule number one. After finding the end of the flagpole's shadow, draw a line to the vanishing point. The flagpole is used to find the location of the shadow. The vanishing point is used to establish the angle of the shadow (Figure 22.3).

Rule Three

Shadows of angled lines are found by locating end points (finding the beginning and end of the shadow) and then connecting the dots. Angled lines can be difficult. They do not follow the ground line, and they do not go to any easily found vanishing point. Again, use the flagpole technique and rule number one to find the end points (Figures 22.4–5).

Rule Four

Vertical lines cast vertical shadows. The pole and the wall are parallel, so the shadow is parallel to the pole. A vertical line casting a shadow on a vertical wall creates a vertical shadow (Figure 22.6).

Rule Five

A horizontal line casting a shadow on a vertical surface is a little more challenging than the previous examples. The shadow is typically at an angle but not necessarily the same as the light

angle. To plot this angle, find the shadow of the end points, then connect the dots. Finding the end points can be straightforward (Figure 22.7) or a little more difficult (Figure 22.8). Sometimes these shadows fall across several surfaces. Finding the end points in these situations can be very difficult indeed, as there are many possible scenarios.

Begin by plotting the shadow of a horizontal line that falls across two surfaces (a horizontal and a vertical surface). First, use rule number two to find the horizontal shadow. Then locate the intersection of the horizontal shadow and the vertical surface. Connect the end points (Figure 22.7).

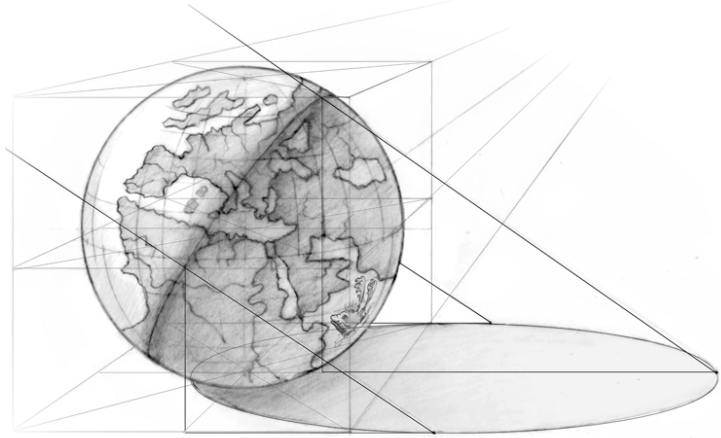
304. 305. If the shadow does not hit the vertical surface, then there is no intersection at the wall. With no intersection, how is the second end point found? There are two solutions to this problem: extend the wall to the shadow (Figure 22.8) or project the shadow to the wall (Figure 22.9).

Rule Six

Angled lines are found by plotting the end points. Draw flag poles from the end points, plot the shadow of the flag poles, and connect the end points (Figure 22.10).

Rule Seven

Plotting shadows on angled surfaces is no different than plotting shadows of angled lines. Find, and then connect, the end points. Anything that is not parallel or perpendicular to the ground plane will require plotting end points. Whether it is the line casting the shadow, or the surface the shadow is cast on, end points will need to be found (Figure 22.11).



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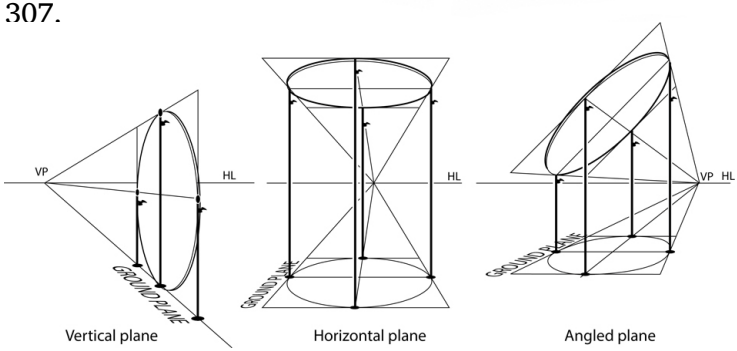


Figure 23.1 Draw flagpoles from points along the curve, stopping at the ground plane. The more flagpoles that are drawn, the more accurate the shadow will be. **Return to text.**⏎

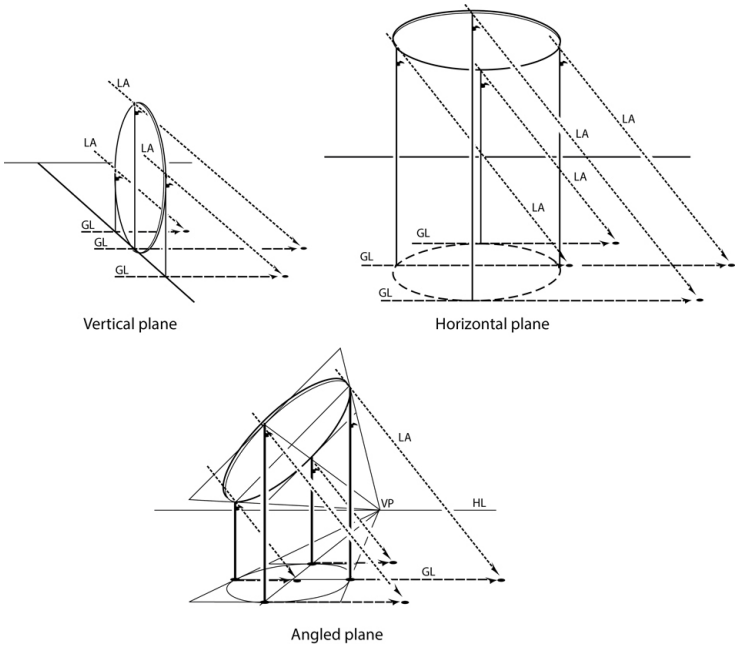
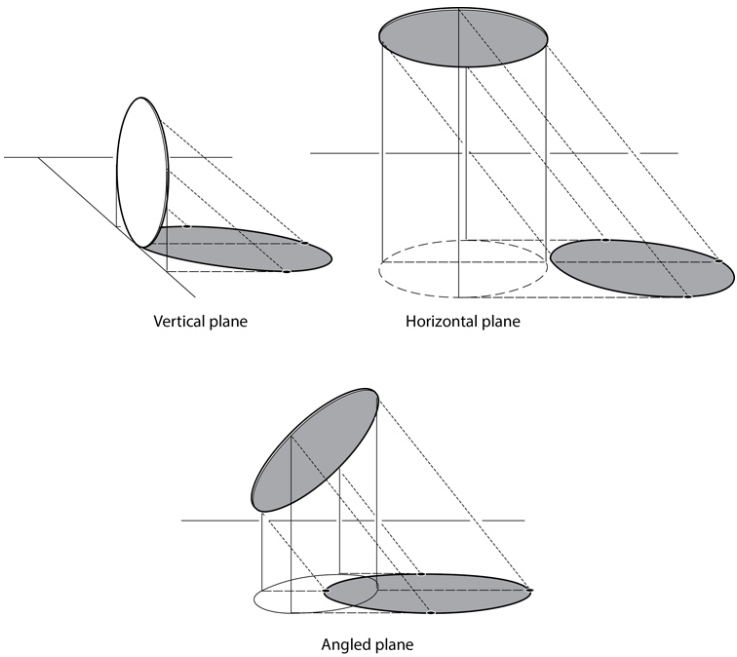


Figure 23.2 Plot the intersection of the light angle and the ground line. Plot as many points as necessary to create an accurate shadow. **Return to text.**⏎ 309.



Figure

23.3 Connect the dots from the intersection of the light angle and ground line to create the shadow. **Return to text.**⏎ 310.

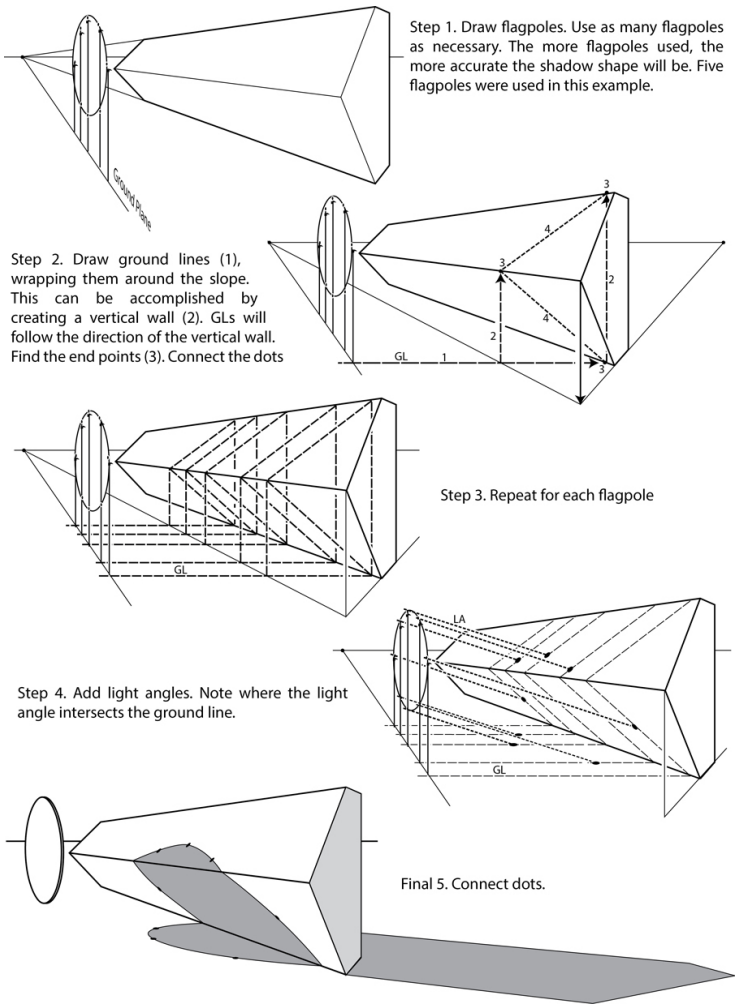


Figure 23.4 Plotting shadows that fall across multiple surfaces can be challenging. **Return to text.**⏎ 311.

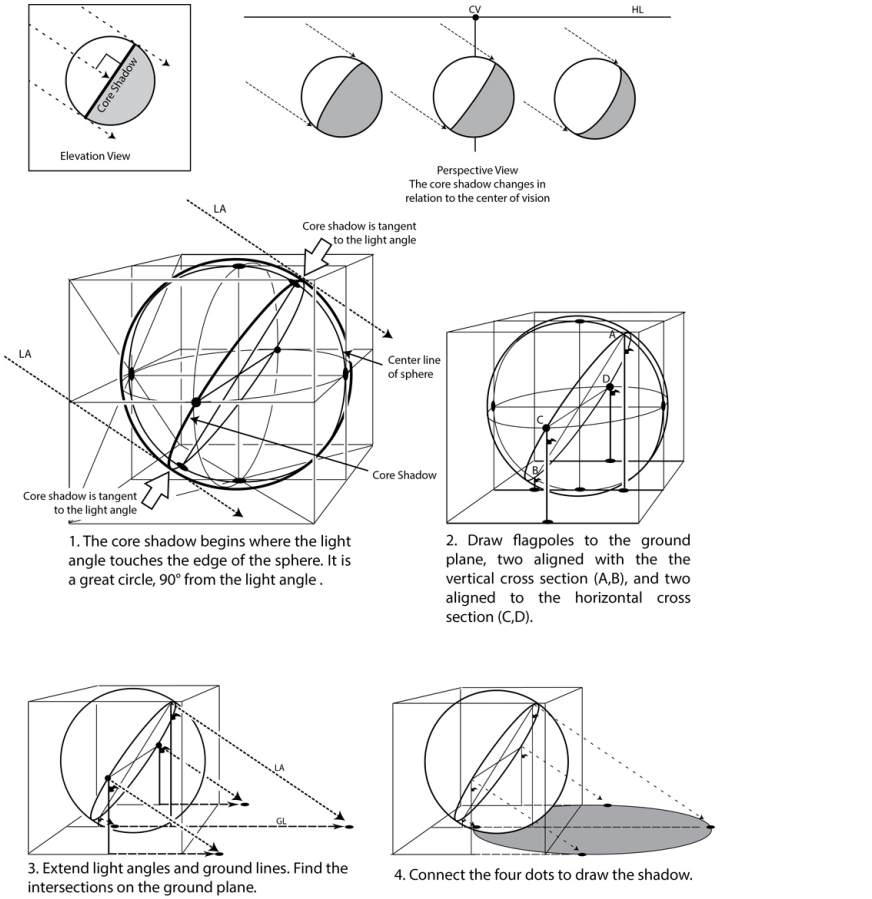


Figure 23.5 Plotting shadows that fall across multiple surfaces can be challenging. **Return to text.**⏎ 312. 313.

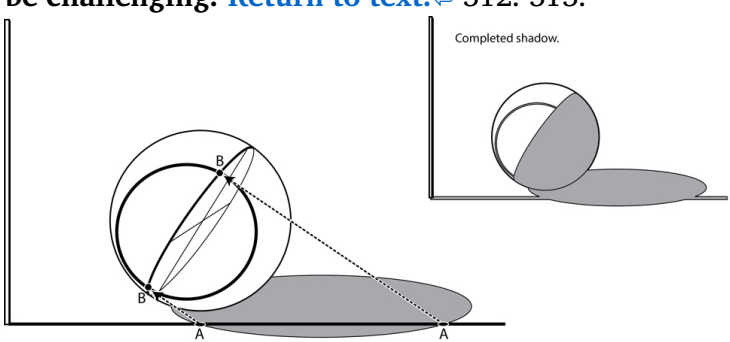


Figure 23.6 A cast shadow follows the shape of the sphere. **Return to text.**⏎ 314.

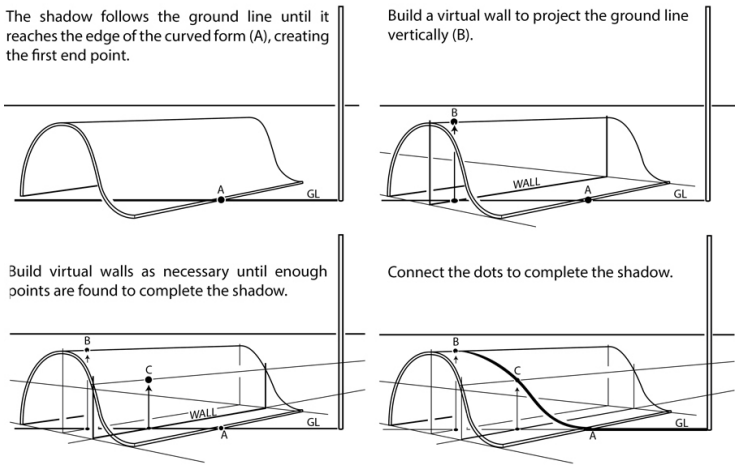


Figure 23.7 The shadow was first drawn on the floor then projected to the curved surface. **Return to text.**⏎

chapter 23
Shadows of Round, Spherical, and Curved Objects

DOI: 10.4324/9781003488101-32

308. Shadows of round or any curved object are found by placing flagpoles at various points along the curve (Figure 23.1), plotting shadows for each flagpole (Figure 23.2), then connecting the dots to create the shadow (Figure 23.3). All curved lines, whether vertical, horizontal, or angled, use the same procedure. More challenging shapes are created when shadows fall across multiple surfaces. Find and connect end points to resolve the shape (Figure 23.4).

Shadows of Spheres

It may be useful to review the chapter on drawing spheres, as it is helpful to know how to draw a sphere before drawing its shadow. Because light angles originate from a point at infinity when natural light is used, the terminator (the line that separates light from dark) is a great circle. Light angles touch the sphere at its widest point (Figure 23.5, top). With artificial light, the core shadow becomes progressively smaller as the light angle moves closer to the sphere (see Chapter 26, Figure 26.6). The sphere's terminator is tangent to the intersection of the light angle and the edge of the sphere. The closer the light source is to the sphere the smaller the terminator.

The cast shadow of a sphere is plotted by drawing flagpoles along the core shadow (Figure 23.5, middle right). Plot the shadow of each flagpole (Figure 23.5, bottom left). Then connect the dots (Figure 23.5, bottom right). Plotting the shadow of a sphere is the same as plotting the shadow of an ellipse, as the core shadow is elliptical.

Shadows on Spheres

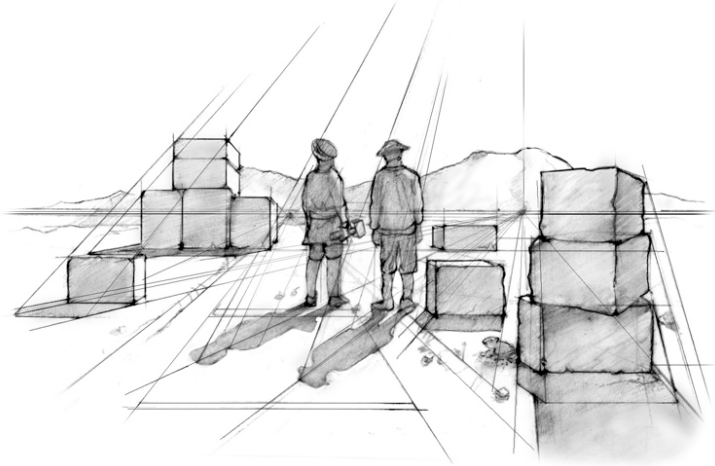
The shadow of a straight line, cast on the surface of a sphere, is always circular. It follows the shape of the sphere. Parallel light creates cast shadows parallel to the picture plane. These shadows are a true half circle, stopping at the core shadow (Figure 23.6). Shadows not parallel to the picture plane strike the sphere at an angle and are elliptical.

One of the easiest ways to locate a cast shadow falling across a sphere is to find the intersection of the cast shadow and the core shadow on the ground plane (Figure 23.6, A). Then, using the light angle, project the intersection back to the sphere (Figure 23.6, B).

Shadows on Curved Surfaces

Plotting shadows that fall across curved surfaces requires the same creative and analytical problem-solving skills. As with all curved forms, end points are plotted and then connected. The

more points that are plotted, the more accurate the shadow. To find these points, it is often helpful to first draw the shadow on a flat plane, then wrap the shadow around the curved surface by finding intersections. This can require some clever maneuvering (Figure 23.7).



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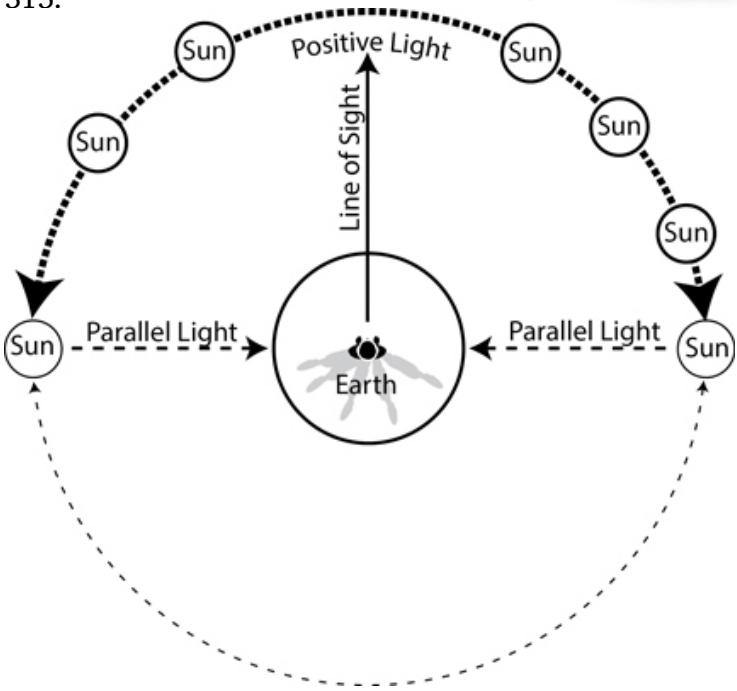


Figure 24.1 Positive light is from a natural light source in front of the viewer. **Return to text.**⏎

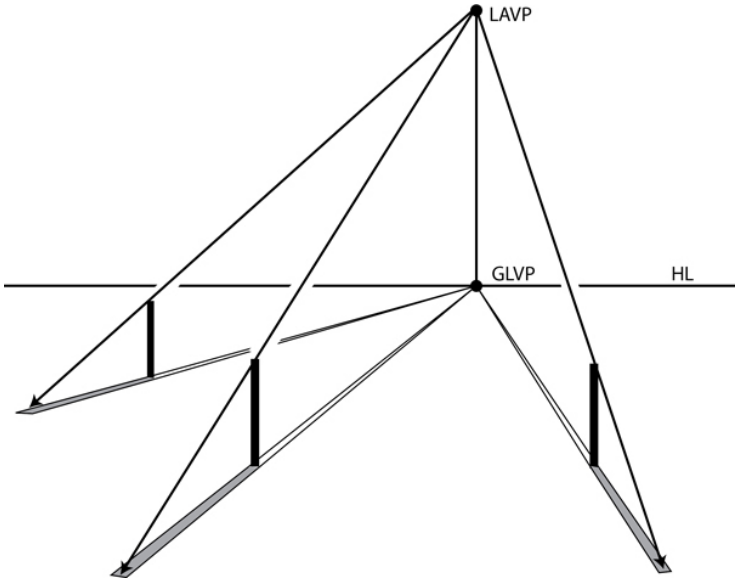


Figure 24.2 Align the light angle vanishing point with the ground line vanishing point. **Return to text.**⏎

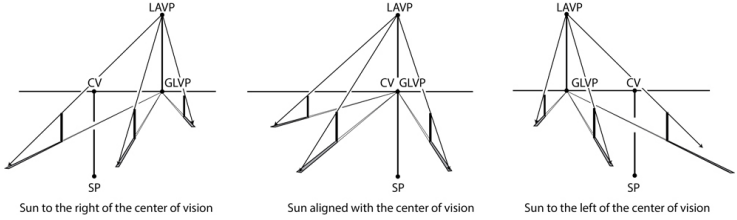


Figure 24.3 The ground line vanishing point can be located anywhere along the horizon line. **Return to text.**⏎ 317.

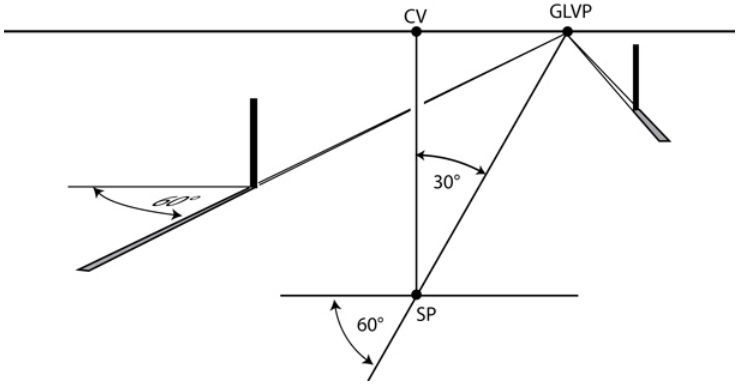


Figure 24.4 Create specific ground line angles by projecting the desired angle from the station point. In this example, the

sun is 30° to the right of the center of vision. This creates shadows 60° to the horizontal. **Return to text.**⏎ 318.

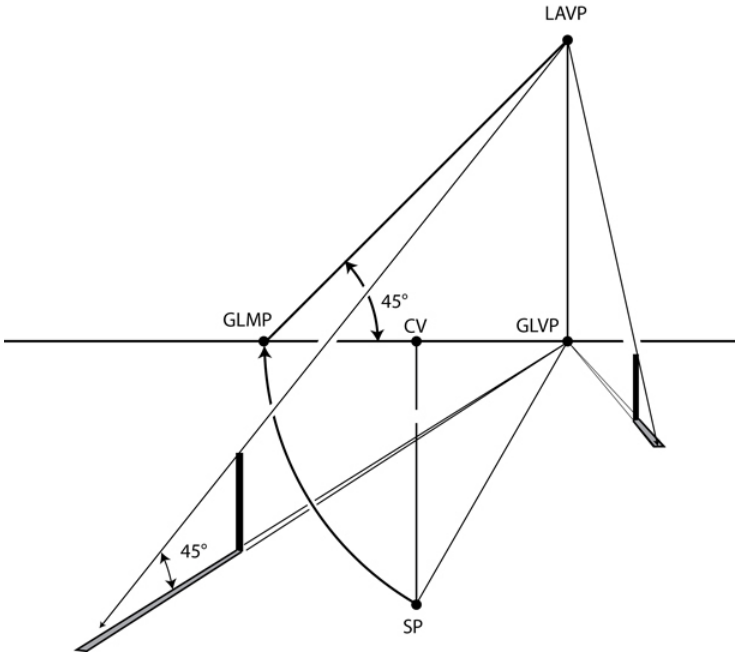


Figure 24.5 To create a specific light angle, first plot a ground line measuring point (GLMP). True angles drawn from the ground line measuring point create a light angle vanishing point, which draws those same angles in perspective. **Return to text.**⏎

chapter 24
Positive Shadows

DOI: 10.4324/9781003488101-33

316. When the sun is in front of the viewer, objects are backlit and shadows are angled forward, away from the horizon line. As the position of the sun moves farther to the left or right, the

shadows become more horizontal, closer to the angle of the horizon line, and closer to being parallel. Positive shadows appear when the light source is anywhere within 90° of the center of vision (Figure 24.1).

Positive Shadow Components

Ground Line Vanishing Point

The ground line is now foreshortened and has a vanishing point. The ground line vanishing point (GLVP) is always placed on the horizon line (Figures 24.2–24.3).

Light Angle Vanishing Point

The light angle vanishing point (LAVP) represents the light source. It is aligned with and placed directly above the ground line vanishing point (Figures 24.2–24.3).

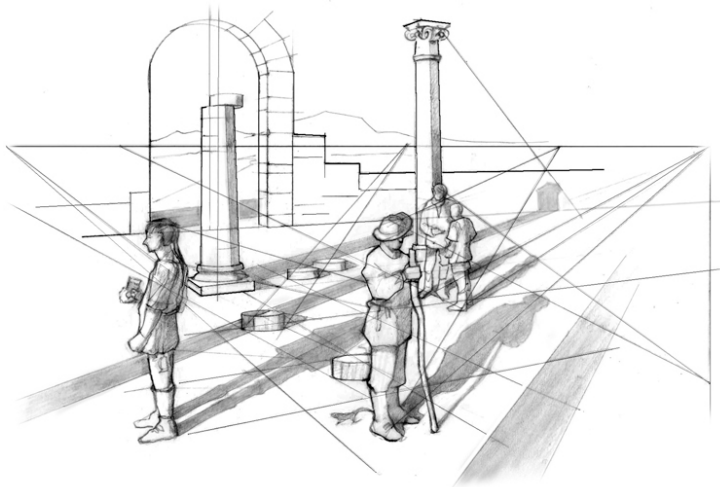
Angle of Shadow

The location of the ground line vanishing point determines the angle of the shadow. Approach the ground line vanishing point like any other vanishing point. A shadow is nothing more than a horizontal line. Drawing a specific ground line angle is the same as drawing any horizontal angle. For example, if the sun is 30° to the right of the center of vision, make a 30° angle from the station point to the horizon line. This ground line vanishing point will draw shadows at a 30° angle to the line of sight, or 60° from horizontal (Figure 24.4).

Angle of Light

The location of the light angle vanishing point determines the length of the shadow. A light angle vanishing point closer to the horizon line produces a longer shadow. A light angle vanishing farther from the horizon line produces a longer shadow. To illustrate a specific time of day, the light angle vanishing point must be properly positioned. Early morning or late evening

light requires an oblique light angle, while mid-afternoon suggests a steeper light angle. Drawing a specific light angle is the same as drawing any incline. The light angle vanishing point can be treated like any auxiliary vanishing point. For example, if the sun is 45° above the horizon line, first make a ground line measuring point (true angles for inclines are found at measuring points). Then draw a 45° angle, intersecting a point directly above the ground line vanishing point (Figure 24.5). Review Chapter 9 for more information about inclines.



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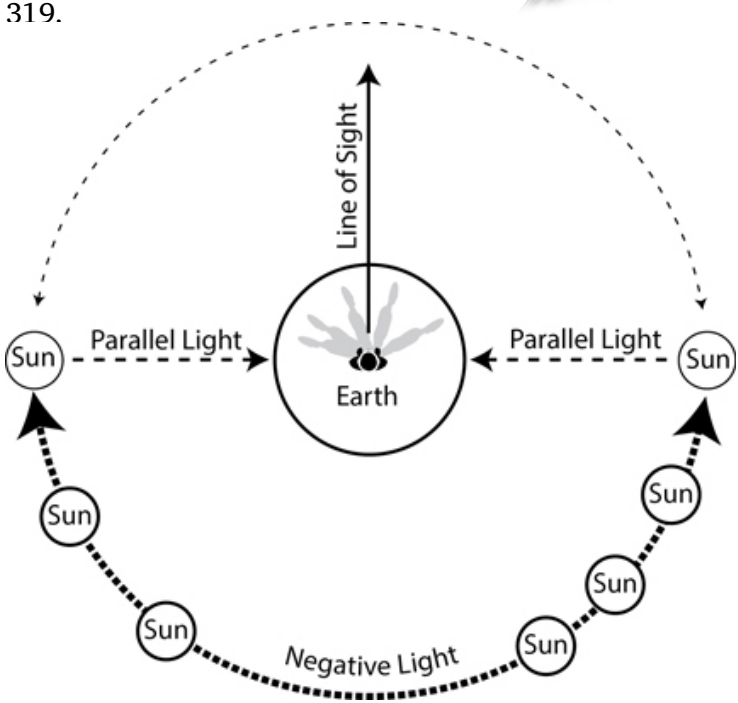

Figure 25.1 Negative shadows occur when the light source is behind the viewer. **Return to text.**⏎

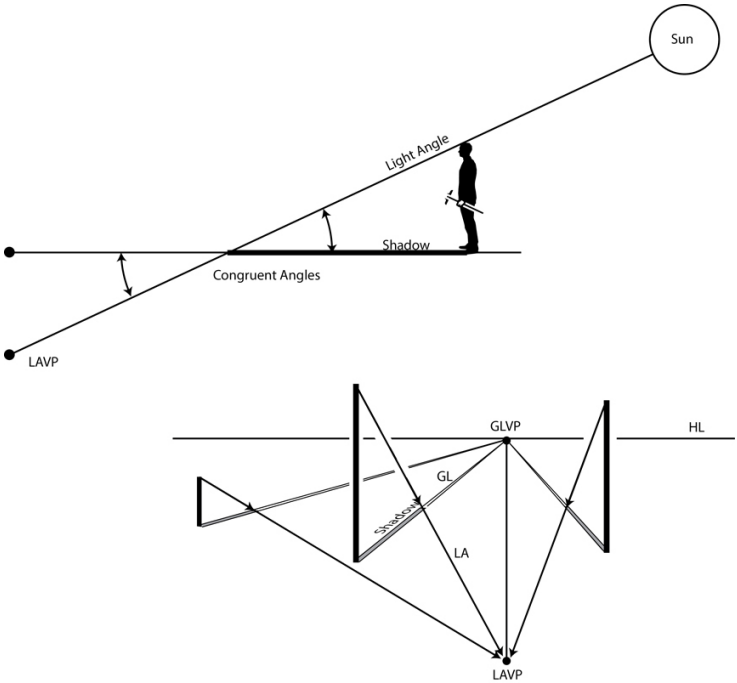

Figure 25.2 Negative shadows require the light angle vanishing point to be below the horizon line, creating congruent angles to the light source located above and behind the viewer. **Return to text.**⏎ 321. 322.

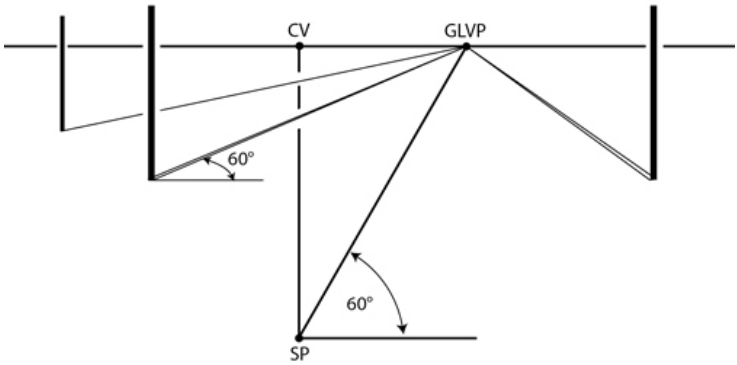

Figure 25.3 Ground line angles are found from the station point. **Return to text.**⏎

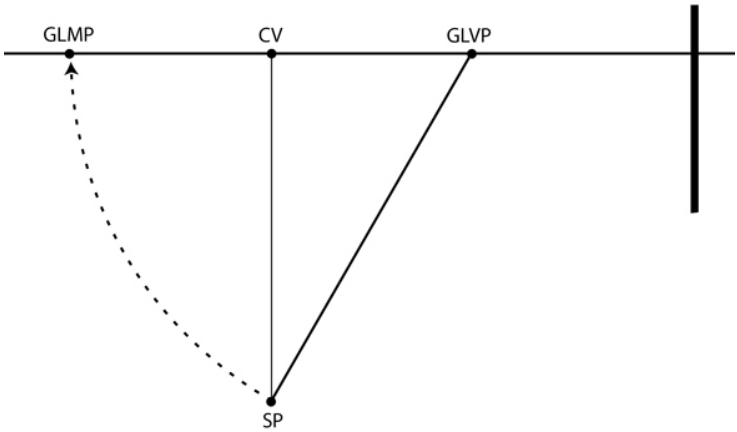

Figure 25.4 A ground line measuring point is needed to locate the light angle vanishing point. **Return to text.**⏎

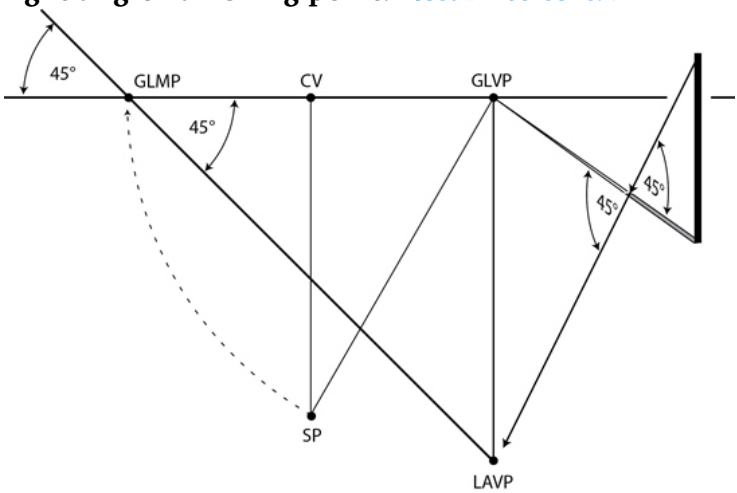

Figure 25.5 Angles drawn from the ground line measuring point create a light angle vanishing point that draws those same angles in perspective. **Return to text.**⏎

chapter 25
Negative Shadows

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320. Negative shadows appear when the sun is behind the viewer. Shadows are angled backward, toward the horizon line (Figure 25.1).

Negative shadows create an interesting problem. Only things in front of the viewer can be drawn. Points that are behind the viewer's head can't be drawn on the paper (the exception being curvilinear perspective). So how can the light source be represented when the light source is behind the viewer? Using some creative thinking and an understanding of geometry–mainly an understanding of geometry–can unlock this problem.

Negative shadows are caused by light rays coming over the viewer's shoulder. These rays are at a specific angle to the ground. Imagine the light rays continuing underground, beyond the ground plane, continuing to infinity, and leading to a vanishing point below the horizon line. This is the light angle vanishing point. This vanishing point creates congruent angles to the light source. In this scenario, the light angle vanishing point is not the light source itself but a point below, which draws the same angle as the light source (Figure 25.2).

Creating Negative Shadows

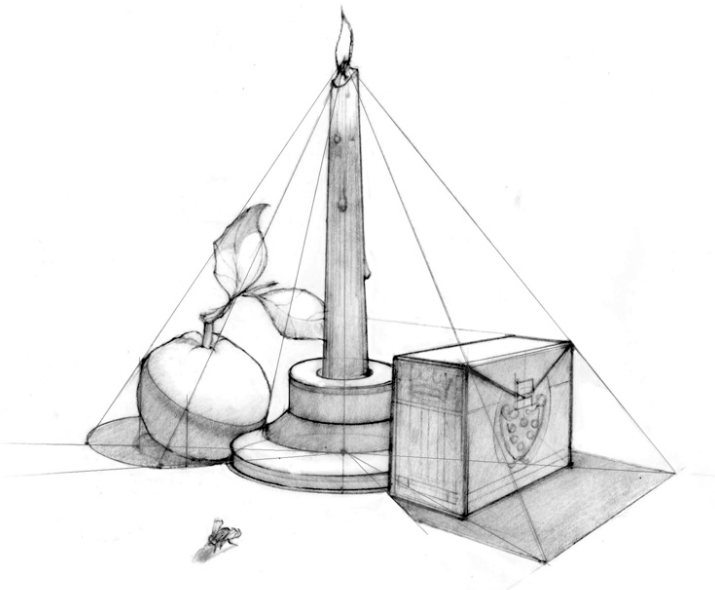
Angle of the Shadow

Use the station point to determine the angle of the shadow (this is the same technique used when drawing positive shadows). Angles projected from the station point create vanishing points that draw that same angle in perspective (Figure 25.3).

Angle of the Light

The first step in creating a specific light angle is to create a ground line measuring point (Figure 25.4). Finding a specific light angle vanishing point follows the same procedures as finding an auxiliary vanishing point. For example, if the light

source is to be 45° above the horizon, project that angle from the ground line measuring point. Negative shadows require the light angle vanishing point to be below the horizon line (Figure 25.5).



323.

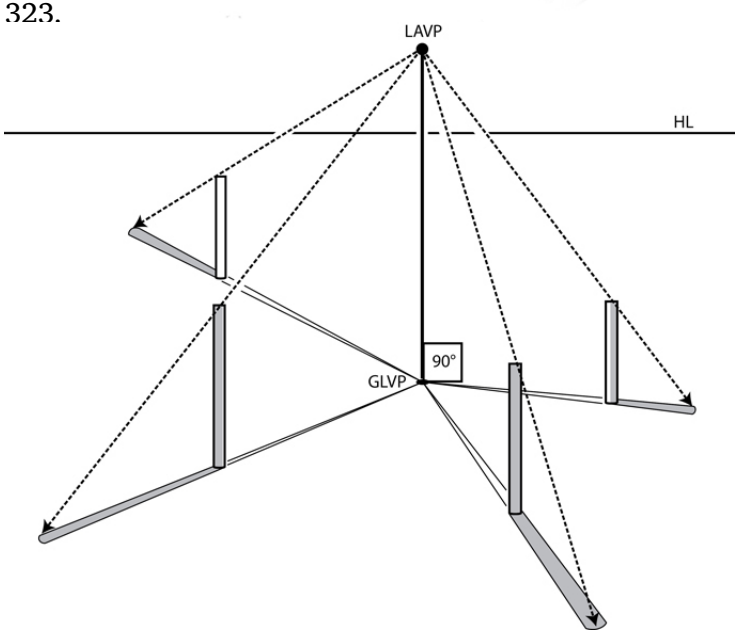


Figure 26.1 Converging shadows radiate around the ground line vanishing point. The ground line vanishing point is always 90° from the light source. **Return to text.**⏎

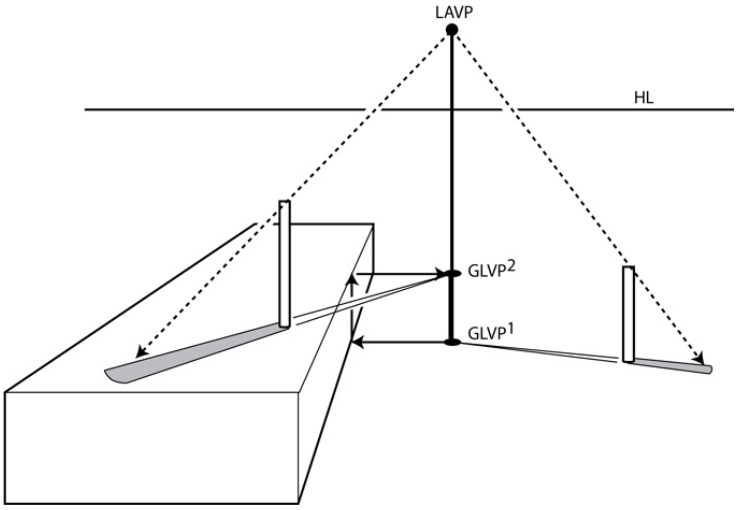


Figure 26.2 The ground line vanishing point must be at the same level as the surface the shadow is on. **Return to text.**⏎ 325.

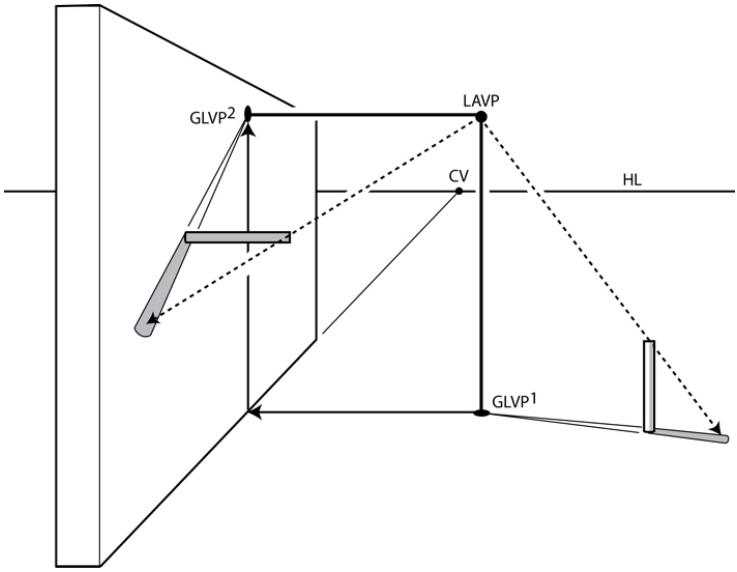


Figure 26.3 Ground line vanishing points can be on vertical surfaces. 326.

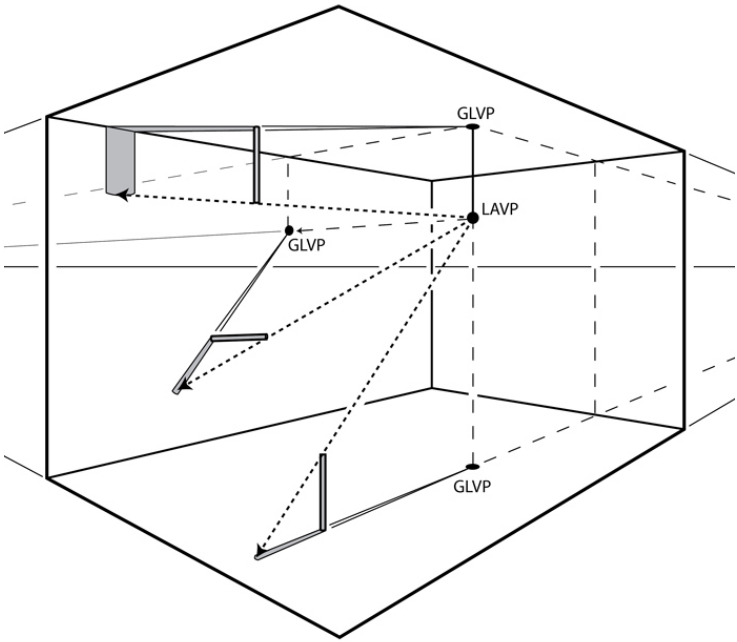


Figure 26.4 Ground line vanishing points are located 90° from the light source and on the same surface as the object casting the shadow. **Return to text.**⏎

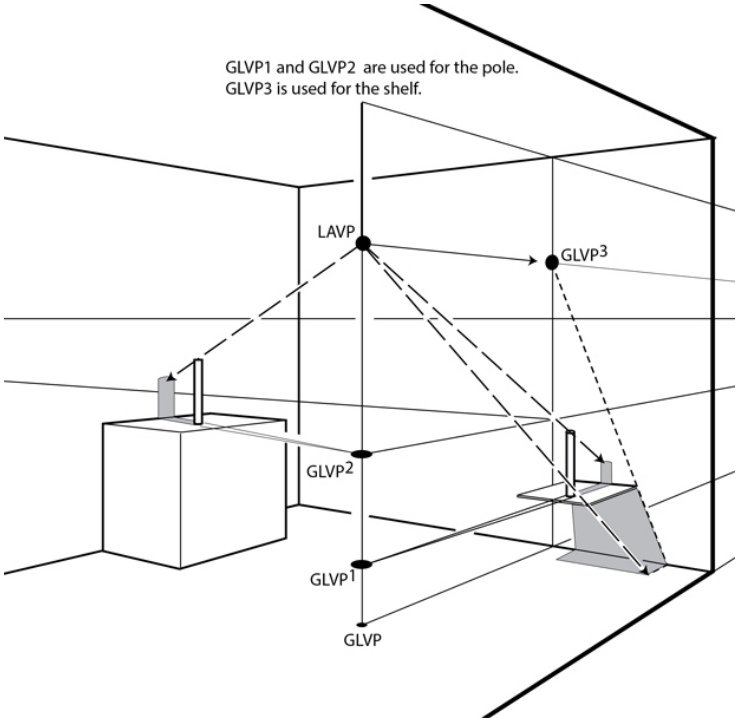


Figure 26.5 Each ground line vanishing point is placed on the same plane as the shadow. **Return to text.**⏎ 327.

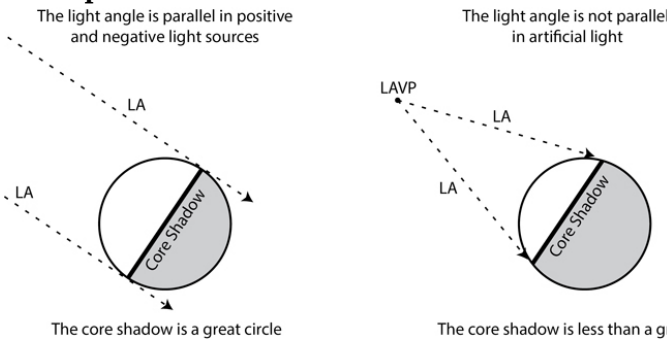


Figure 26.6 Artificial light creates a smaller core shadow. **Return to text.**⏎

chapter 26

Shadows From Artificial Light Sources

DOI: 10.4324/9781003488101-35

324. Natural light is from a source at such a distance that the shadows cast are considered parallel. All lines drawn from the same point on the horizon line are parallel in perspective. Thus, all shadows from a natural sight source are likewise parallel in perspective.

An artificial light source is much closer. The shadows are not parallel but radiate around a point. The shadows become wider as they get farther away from the light source.

Components of Shadows Created From Artificial Light

Light Angle and Ground Line Location

The light angle vanishing point represents the light source. It can be anywhere, but its location determines the placement of the ground line vanishing point.

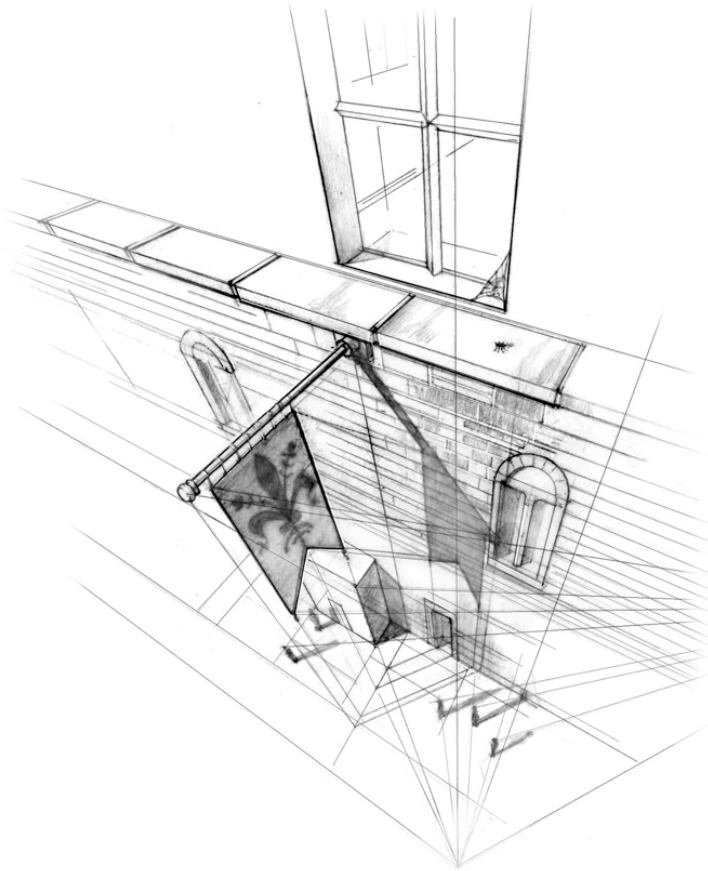
The ground line vanishing point is located 90° from the light source. It is most frequently placed on the surface the shadow is cast upon, typically the ground plane (Figure 26.1). In contrast to natural light, artificial light can have multiple ground line vanishing points. They can be on walls, floors, and ceilings (Figures 26.2–26.5). Shadows at different heights (e.g., shadows on a floor and shadows on a table) have ground line vanishing points at the same height as the surface the objects are on (Figure 26.2).

Spheres

When using parallel, positive, or negative light systems, the

light source is far enough away from the Earth that the rays of light are considered parallel. The light angle strikes a sphere at the widest part (a great circle).

Artificial light is different. The light angle originates from a much closer source, and the light rays radiate from this point. The core shadow will be smaller than a great circle (Figure 26.6).



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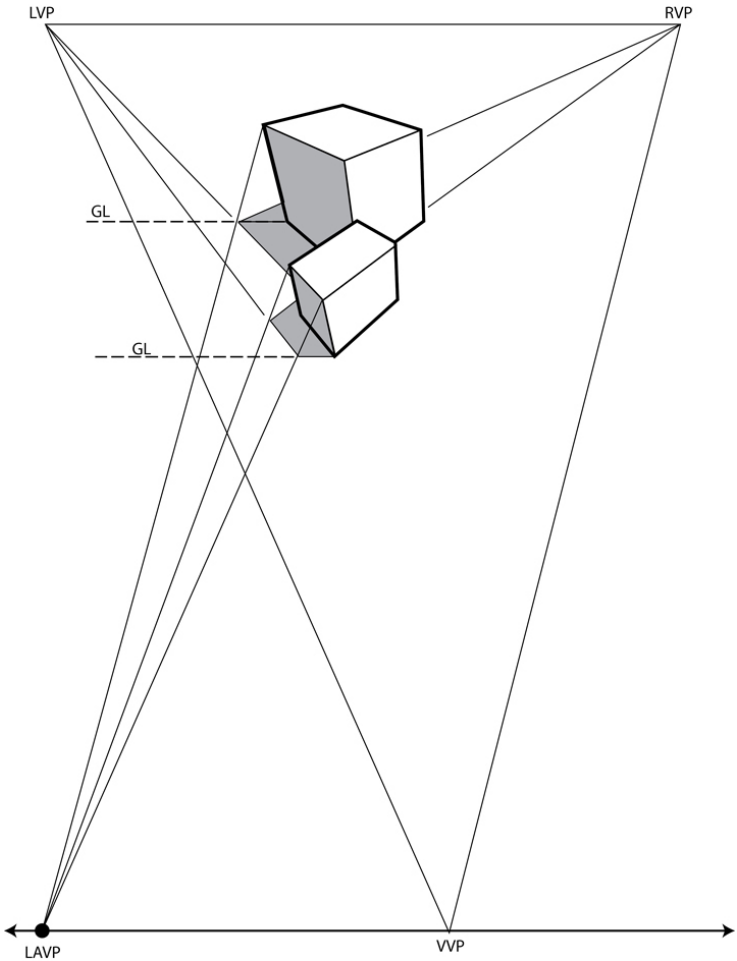


Figure 27.1When the light angle vanishing point is to the left of the vertical vanishing point, the sun is above and to the right of the viewer. **Return to text.**⏎ 330. 331.

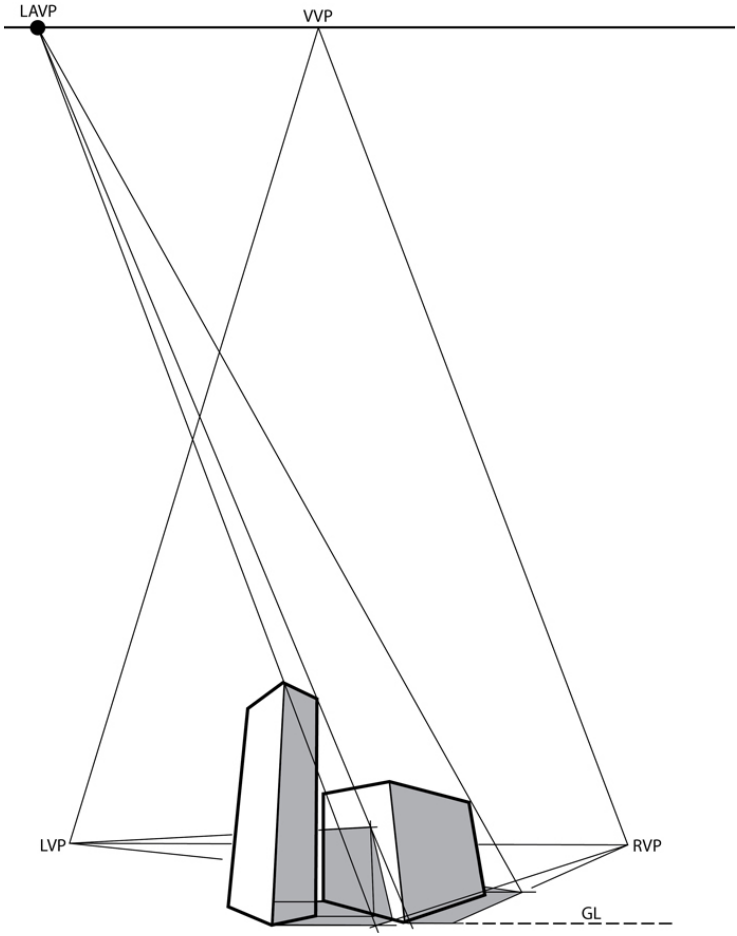


Figure 27.2 Unlike the bird's-eye-view, in a worm's-eye view, the light angle vanishing point represents the location of the sun. **Return to text.**⏎

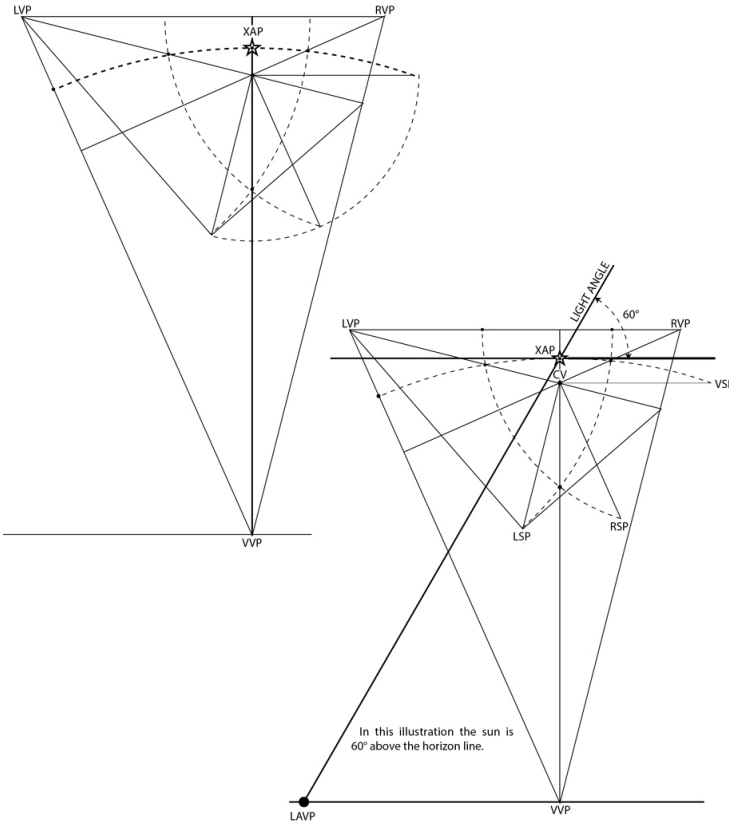


Figure 27.3 Use the *x*-axis point (the point of true angles) to establish a light source at a specific angle. **Return to text.**⏎
332. 333.

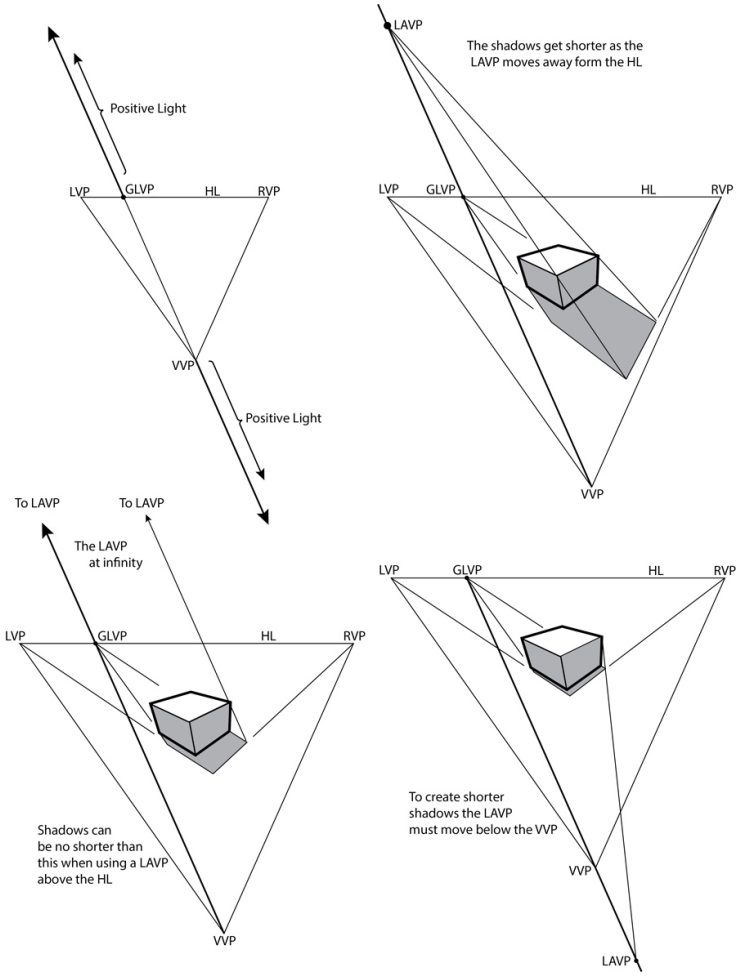
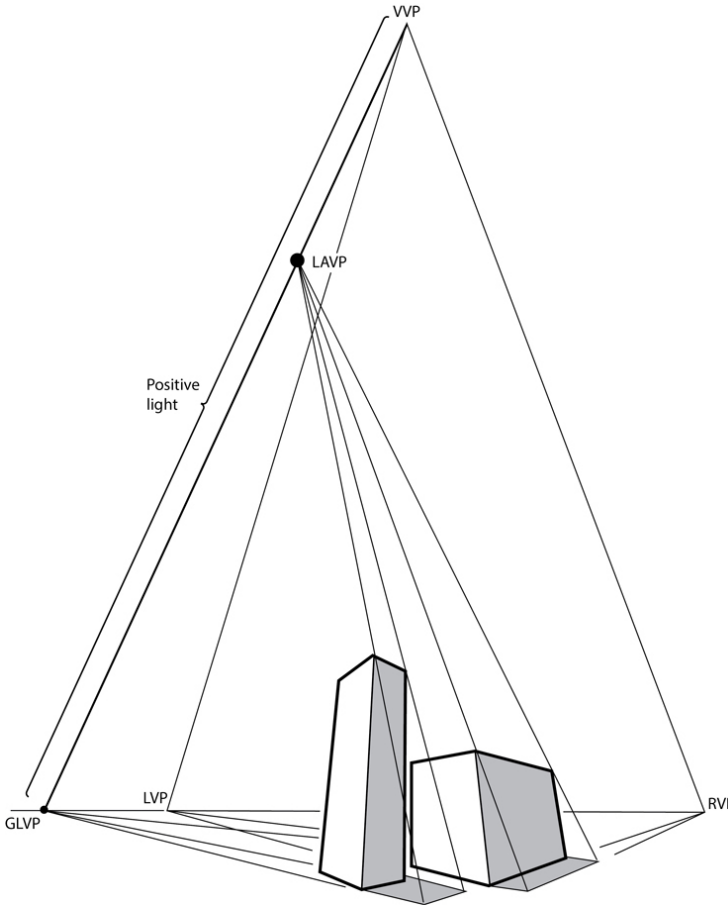


Figure 27.4When drawing positive shadows in a bird's-eye view, the light angle vanishing point is above the horizon line or below the vertical vanishing point. But the ground line vanishing point, light angle vanishing point, and vertical vanishing point are always aligned. **Return to text.**⏎ 334.



335.

Figure 27.5 Positive shadows in a worm's-eye view. The light angle vanishing point and the ground line vanishing point align with the vertical vanishing point. **Return to text.**⏎ 336.

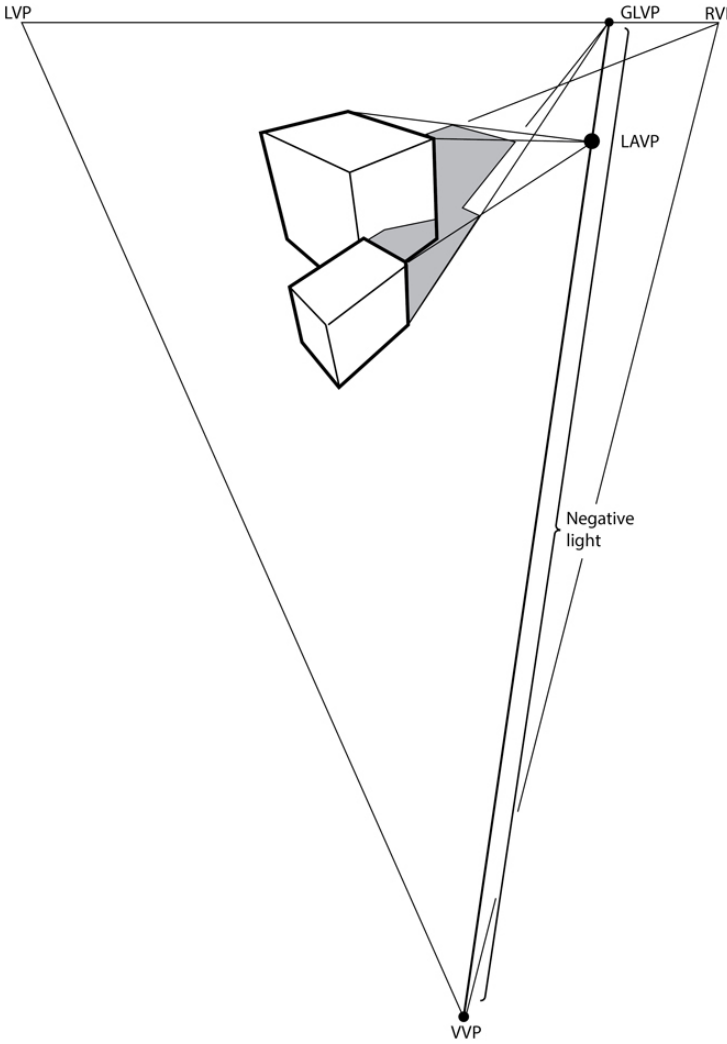


Figure 27.6 When drawing negative shadows in a worm's-eye view, the light angle vanishing point is below the horizon line or above the vertical vanishing point. But the ground line vanishing point, light angle vanishing point, and vertical vanishing point are always aligned. **Return to text.**⏎ 337.

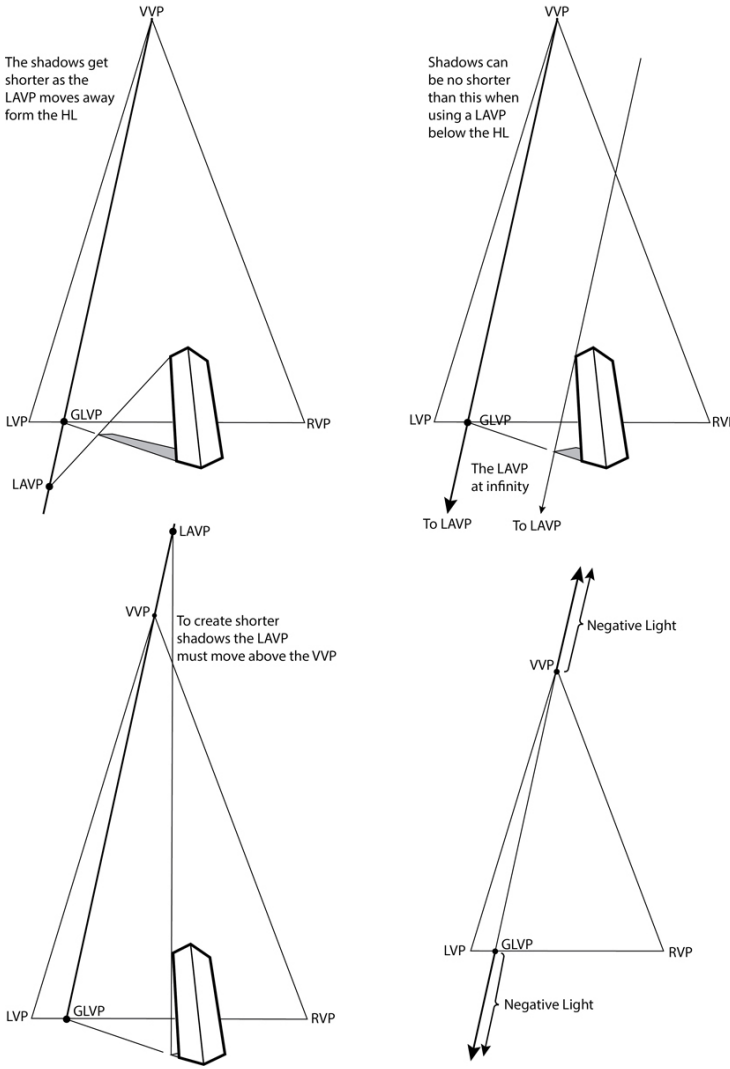


Figure 27.7 When drawing negative shadows in a worm's-eye view, the light angle vanishing point and the ground line vanishing point are aligned with the vertical vanishing point. **Return to text.** ⏎ 338. 339.

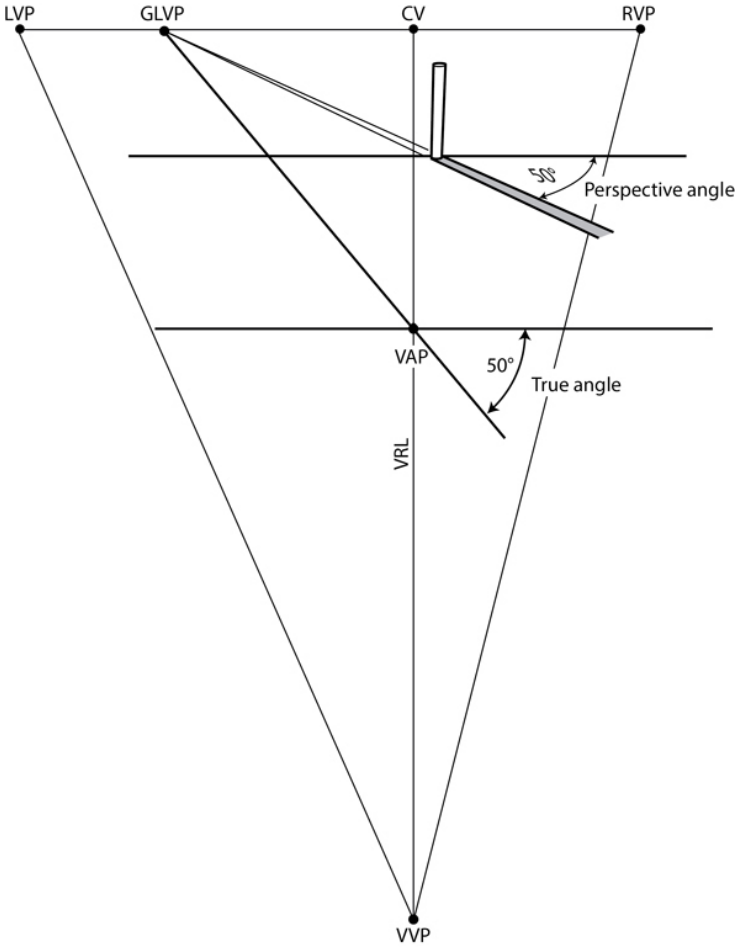


Figure 27.8 Use the vertical axis point to establish a specific ground line angle. **Return to text.**⏎

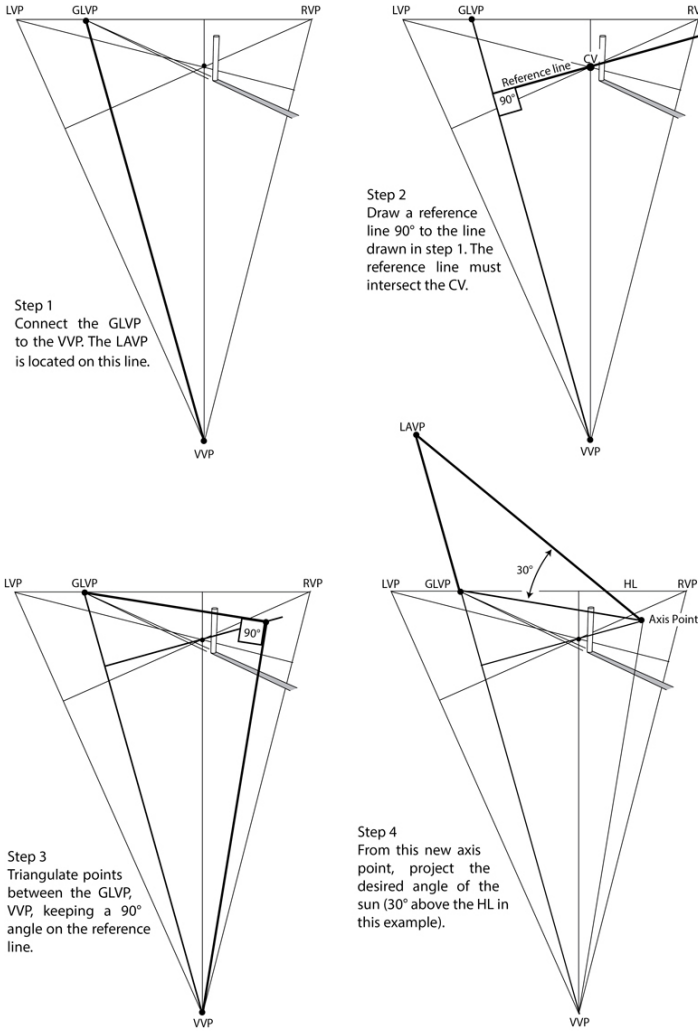
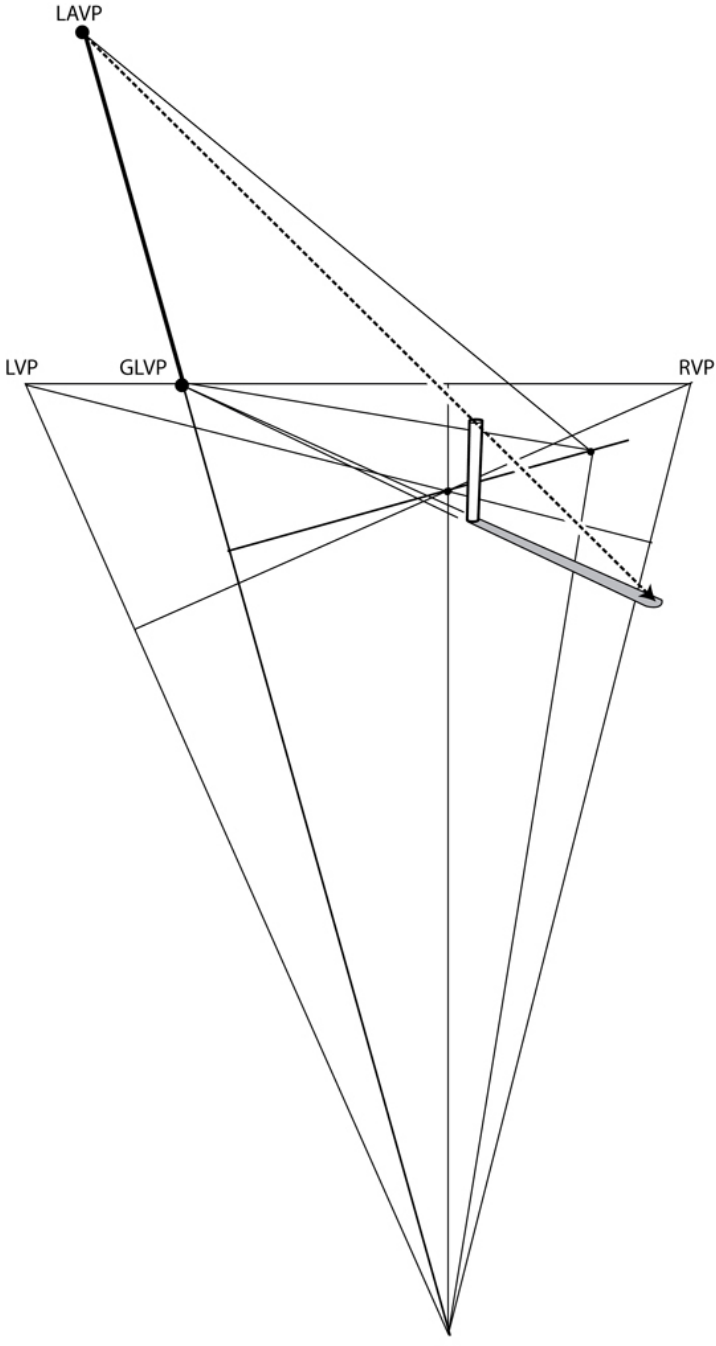


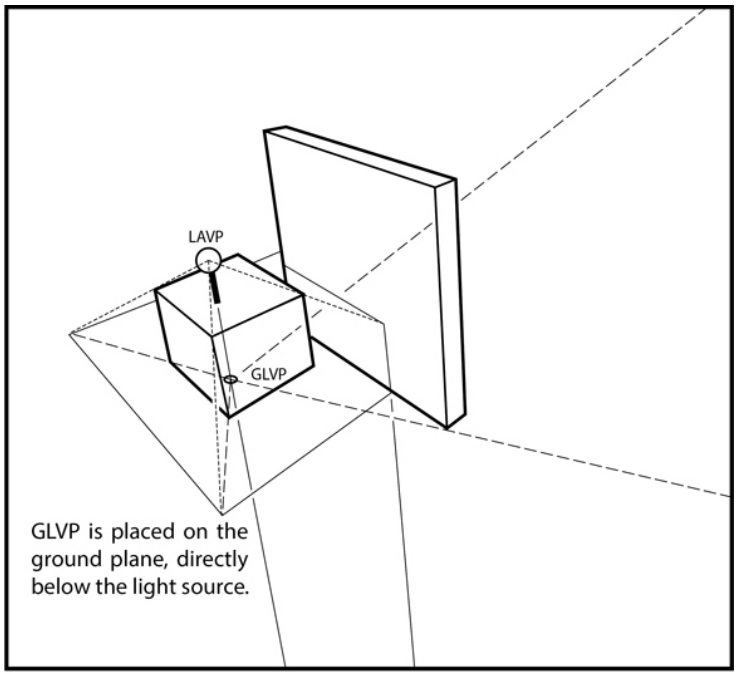
Figure 27.9 Positioning the light angle vanishing point in a specific location requires a new axis point. **Return to text.**

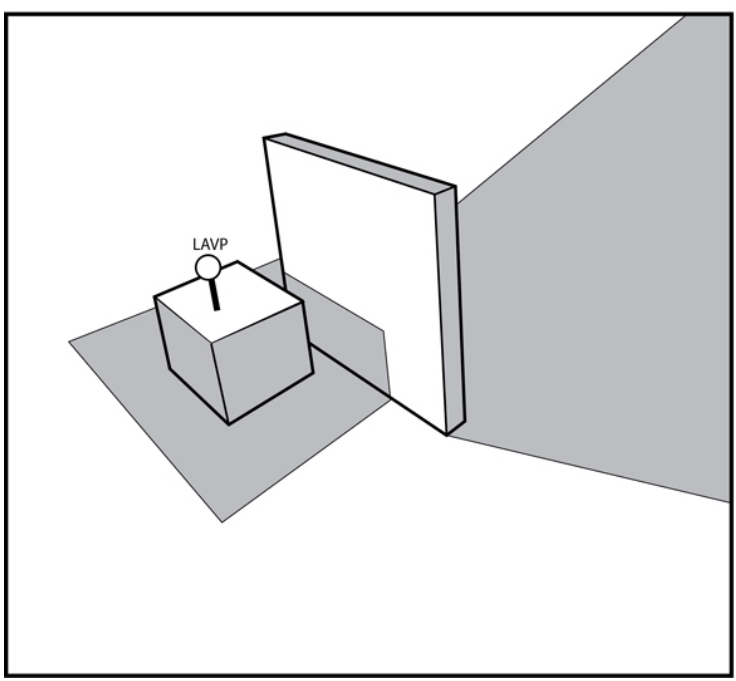


340.

Figure 27.10 The finished shadow. The sun is 40° to the left

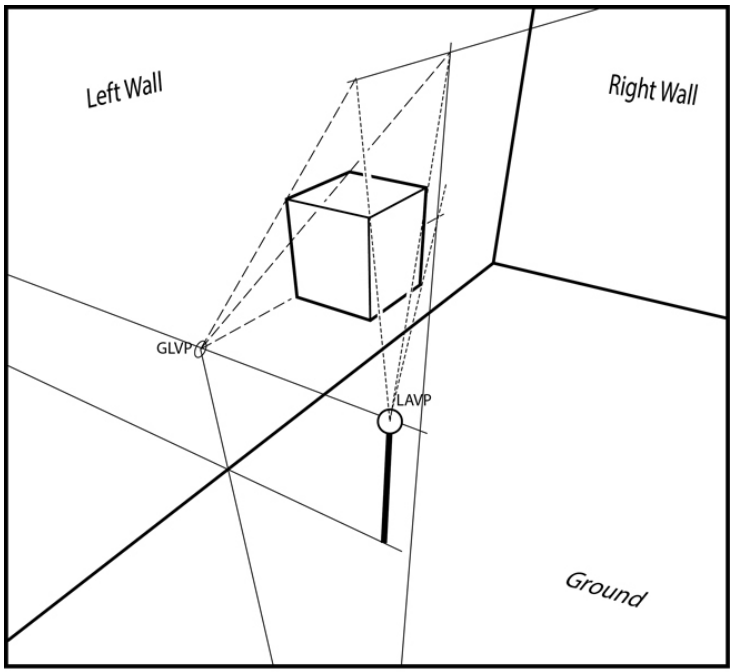
and 30° above the horizon line. **Return to text.**⏎ 341. 342.





Figure

27.11 When drawing shadows from artificial light sources, the ground line vanishing point is located 90° from the light angle vanishing point. Return to text.⏎



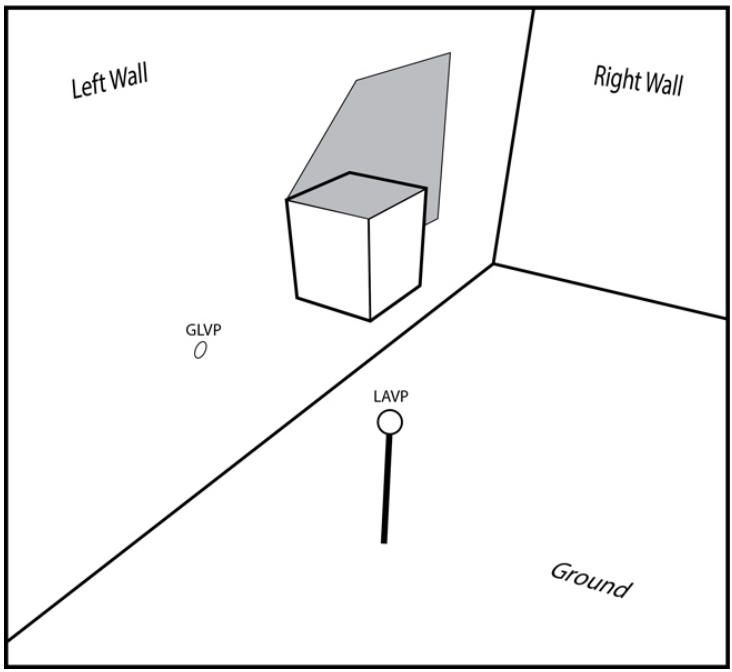


Figure 27.12 Shadows on vertical surfaces have ground line

vanishing points on the same surface as the shadow.
Return to text.⏎ 343. 344.

chapter 27
Three-Point Shadows

DOI: 10.4324/9781003488101-36

329. All the previous shadow rules apply to three-point perspective. But, in three-point perspective, due to the vertical lines being foreshortened, a more complicated situation is created when faced with the task of locating the light angle and ground line vanishing points. The following pages illustrate how to apply natural and artificial light systems in three-point perspective.

Parallel Shadows, Bird's-Eye View

Ground Line

As with one- and two-point perspective, when the sun is 90° from the viewer's line of sight, the ground line is parallel to the picture plane and there is no ground line vanishing point.

Light Angle

Unlike one- and two-point perspective, the light angle is not parallel to the picture plane. In three-point perspective, due to the picture plane being foreshortened, the light angle has a vanishing point. If the sun is directly overhead, light rays are vertical (90° to the ground plane). Since all vertical lines connect to the vertical vanishing point, the vertical vanishing point becomes the light angle vanishing point. If the sun is to the right or left, the light angle vanishing point moves

horizontally to the left or right of the vertical vanishing point (Figures 27.1–27.2).

Location

To place the light source in a specific location, find the point of true angles (this is the same procedure outlined in Figure 17.21). Measure the distance from the vertical vanishing point to the vertical station point. Then transfer that distance to the vertical reference line, establishing the *x*-axis point (Figure 27.3, top). From the *x*-axis point, project the desired angle, locating the light angle vanishing point. For example, if the light source is to be at a 60° angle from the ground plane, project a true 60° angle from the point of true angles (Figure 27.3, bottom).

The light angle vanishing point does not represent the light source, but it does create angles congruent with the light source (review Chapter 25). If the light angle vanishing point is to the right of the vertical vanishing point, the sun is to the viewer's left. Conversely, if the light angle vanishing point is to the left of the vertical vanishing point, the sun is to the viewer's right (Figure 27.1).

Parallel Shadows, Worm's-Eye View

A worm's-eye view is approached the same as a bird's-eye view, only upside down. The procedure is the same. However, in a worm's-eye view, the light angle vanishing point is above the horizon line and does represent the sun's actual location (Figure 27.2).

Positive Shadows, Bird's Eye View

The sun is in front of the viewer. Objects are backlit, and shadows angle toward the viewer.

Ground Line

The ground line vanishing point is located on the horizon line, as it is for all natural light situations.

Light Angle

The light angle vanishing point is aligned vertically with the ground line vanishing point. In three-point perspective, all lines that are 90° to the ground plane connect to the vertical vanishing point. Since the ground line vanishing point and the light angle vanishing point must align vertically, they will both align with the vertical vanishing point (Figure 27.4–27.5).

A light angle vanishing point closer to the horizon line creates a longer shadow. A light angle vanishing point farther away from the horizon line creates a shorter shadow (Figure 27.4 upper right), but only to a point. When the light angle vanishing point is moved to infinity the light angle will be the same as the line that connects ground line vanishing point to the vertical vanishing point. This is the smallest shadow that can be created in this configuration (Figure 27.4 lower left). To create a shorter shadow, the light angle vanishing point must be moved below the vertical vanishing point (Figure 27.4 lower right). The closer the light angle vanishing point moves to the vertical, the shorter the shadow will be. When the light angle vanishing point is at the location of the vertical vanishing point, the light source is directly overhead. The light rays would be parallel with any vertical surface.

Positive Shadows, Worm's Eye View

Ground Line

As with bird's eye view, the ground line vanishing point is placed on the horizon line.

Light Angle

The light angle vanishing point is placed between the horizon line and the vertical vanishing point. The ground line vanishing

point and the light angle vanishing point must be aligned with the vertical vanishing point (Figures 27.5). For longer shadows, move the light angle vanishing point closer to the horizon line. To create shorter shadows, move the light angle vanishing point closer to the vertical vanishing point. Placing the light angle vanishing point on top of the vertical vanishing puts the light source directly overhead. The light rays will be parallel with vertical surfaces.

Negative Shadows, Bird's Eye View

When the light angle vanishing point moves between the vertical vanishing point and the horizon line, the light source is behind the viewer and the shadows project toward the horizon line (Figure 27.6). The closer the light angle vanishing point gets to the horizon line, the longer the shadows will be.

Negative Shadows, Worm's Eye View

Light Angle

The light angle vanishing point is placed below the horizon line or above the vertical vanishing point (Figure 27.7 bottom right). Placing the light angle vanishing point below the horizon line at infinity will create a light angle that is parallel with the line that connects the light angle vanishing point to the vertical vanishing point (Figure 27.7 top right). To create shorter shadows, move the light angle vanishing point above the vertical vanishing point (Figure 27.7 bottom left). Placing the light angle vanishing point on top of the vertical vanishing point puts the light source directly overhead. The light rays will be parallel with vertical surfaces.

Light Source Location

Placing the light source in a specific location requires a solid understanding of three-point angles.

Ground Line

The ground line angle is established using the vertical axis point. For example, to draw a shadow that is 50° from horizontal, draw a true 50° angle at the vertical axis point. Then project that angle to the horizon line (Figure 27.8).

Light Angle

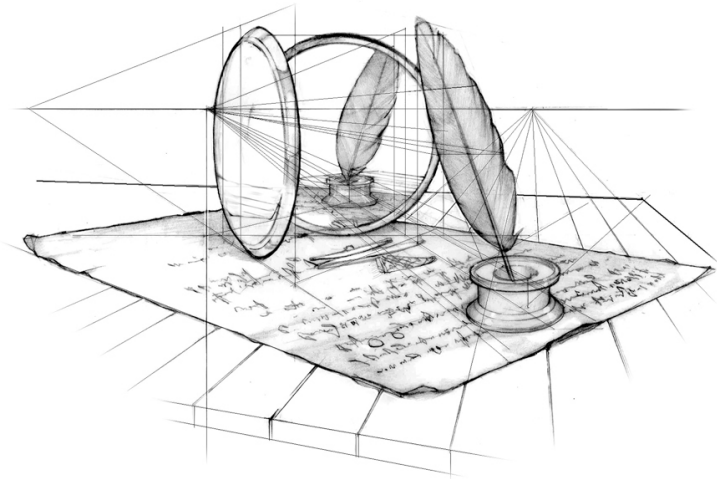
The light angle is a bit more complicated. It involves making a new reference line and a new axis point. Use this procedure for both positive and negative shadows (Figures 27.9–27.10).

Converging Light in Three-Point Perspective

Artificial light in three-point perspective is approached the same as one- or two-point perspective, the only difference being that vertical lines are now foreshortened. Otherwise, the same rules apply (Figures 27.11–27.12).

345. 346.

part ten
Reflections



347.

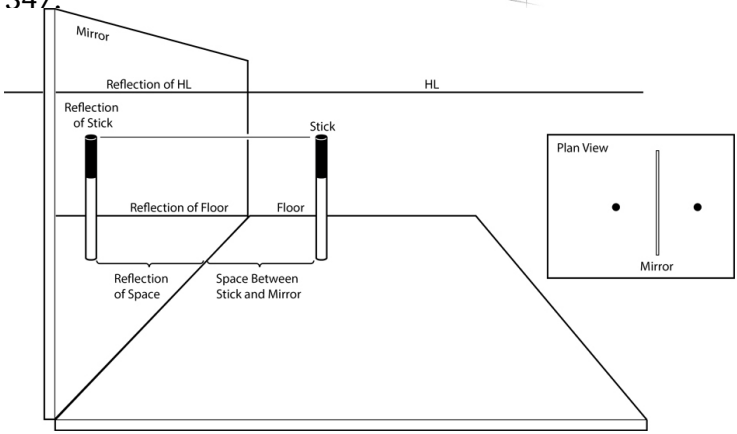


Figure 28.1 Horizontal reflections are not foreshortened. **Return to text.**⏎ 349.

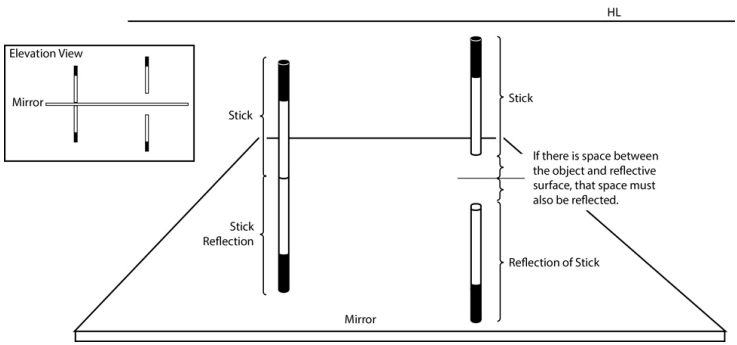
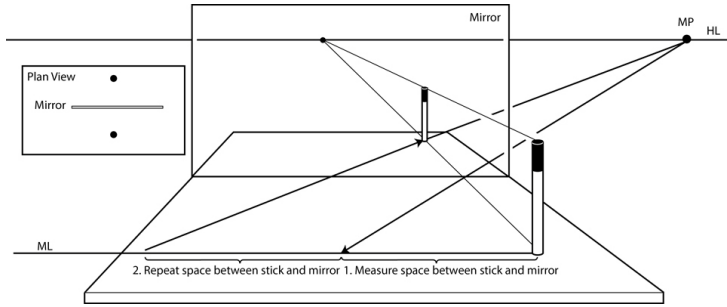


Figure 28.2 Vertical reflections are not foreshortened. **Return to**



text.⏎

Figure 28.3 The distance between the object and mirror is foreshortened. Use a measuring point to reflect the distance. Return to text.⏎

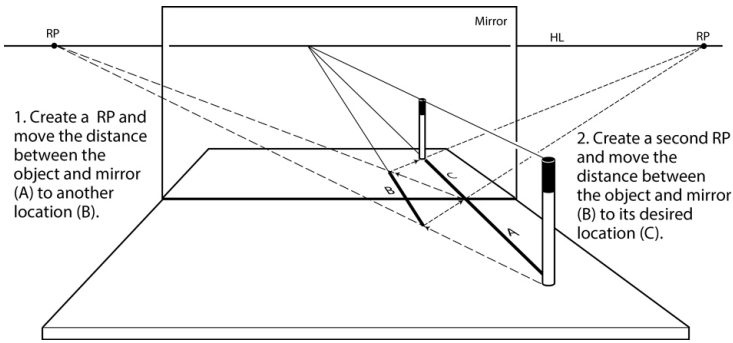


Figure 28.4 A reference point can be used to move parallel lines backward and forward in space. Return to text.⏎ 350.

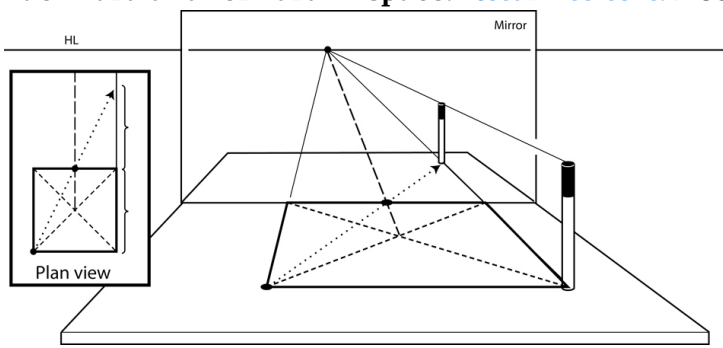


Figure 28.5 Using geometry to plot the distance of the reflection. Return to text.⏎ 351.

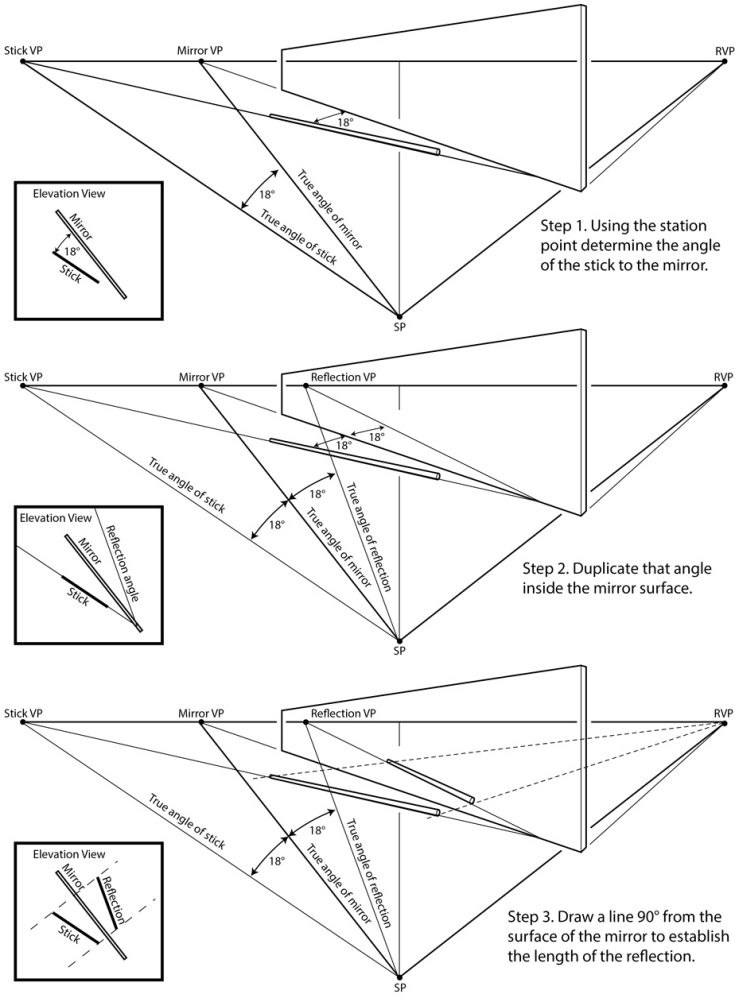


Figure 28.6 Use horizontal angles, plotted from the station point, to draw reflections angled to the mirror. **Return to text.**⏎ 352. 353.

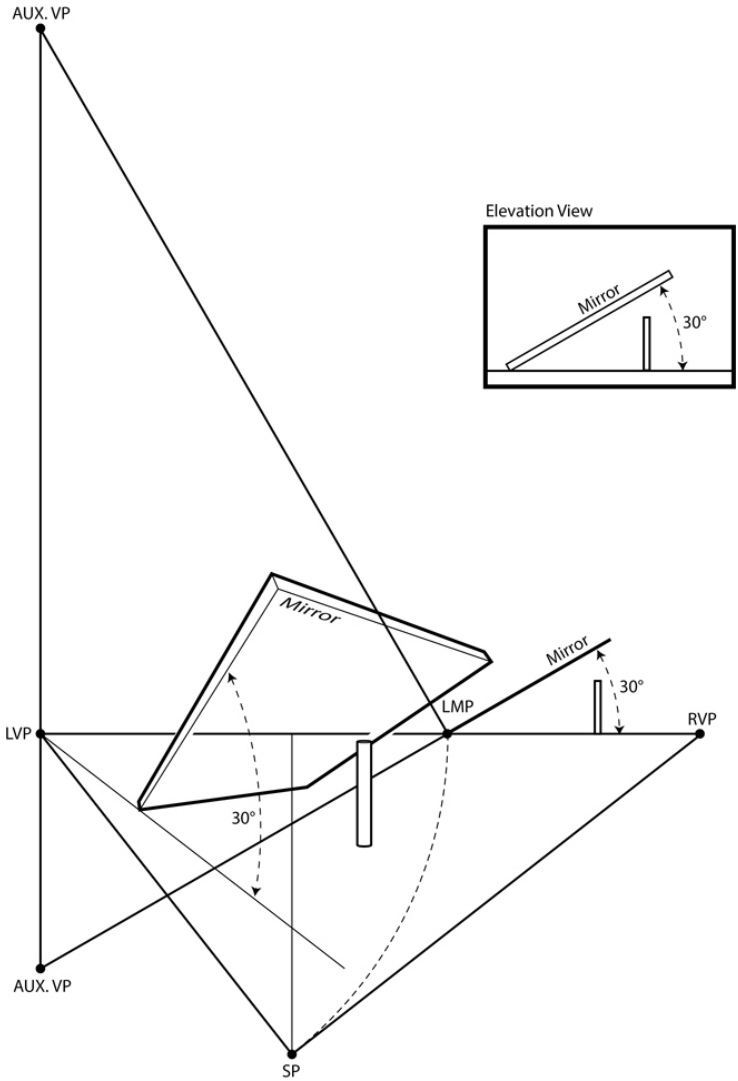


Figure 28.7 The mirror is 30° to the ground plane. Return to text.

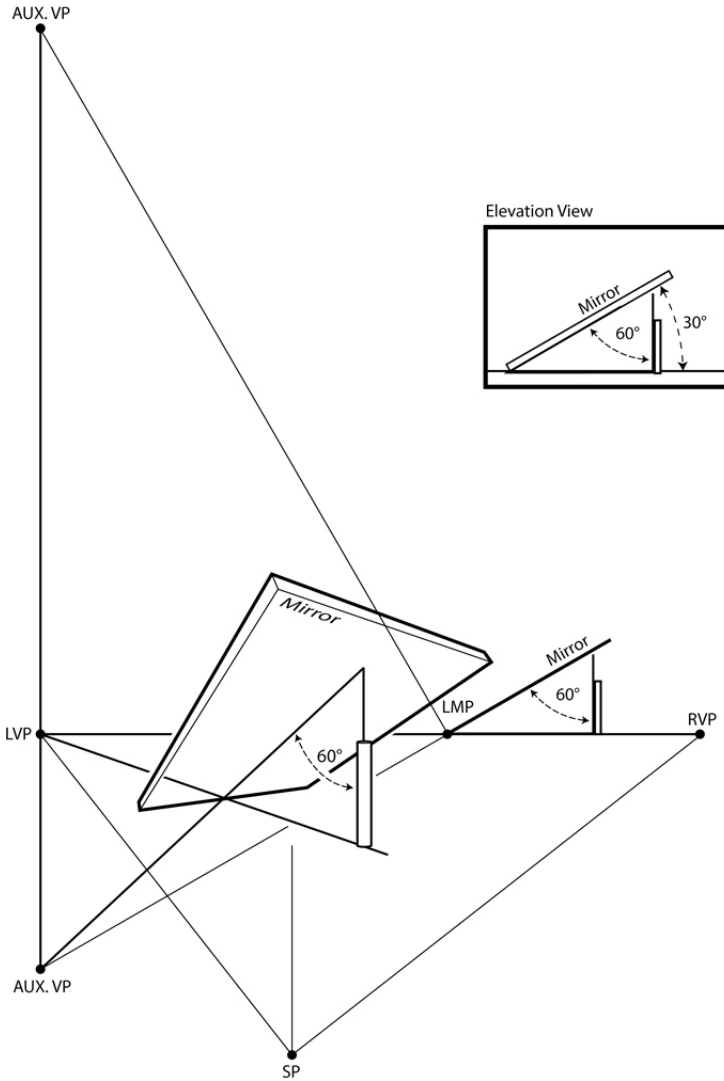


Figure 28.8 The angle of the object to the mirror is 60˚. **Return to text.**⏎ 354.

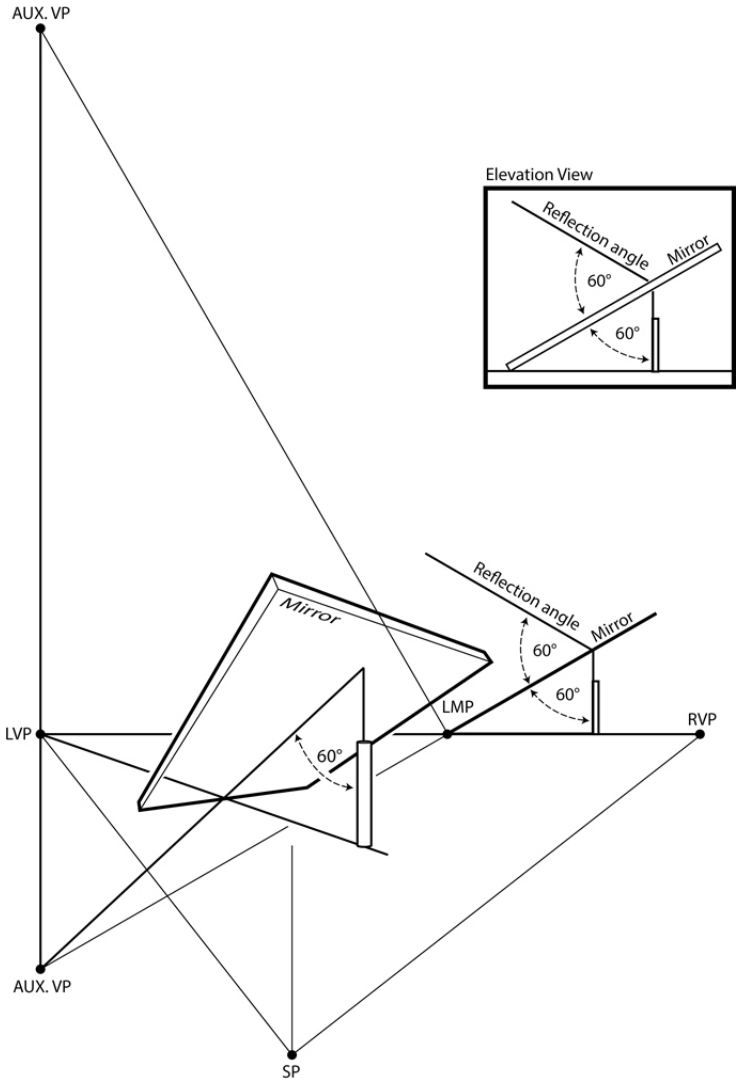


Figure 28.9 If the angle of the object to the mirror is 60˚, then the angle of the reflection to the mirror is also 60˚. **Return to text.**⏎ 355.

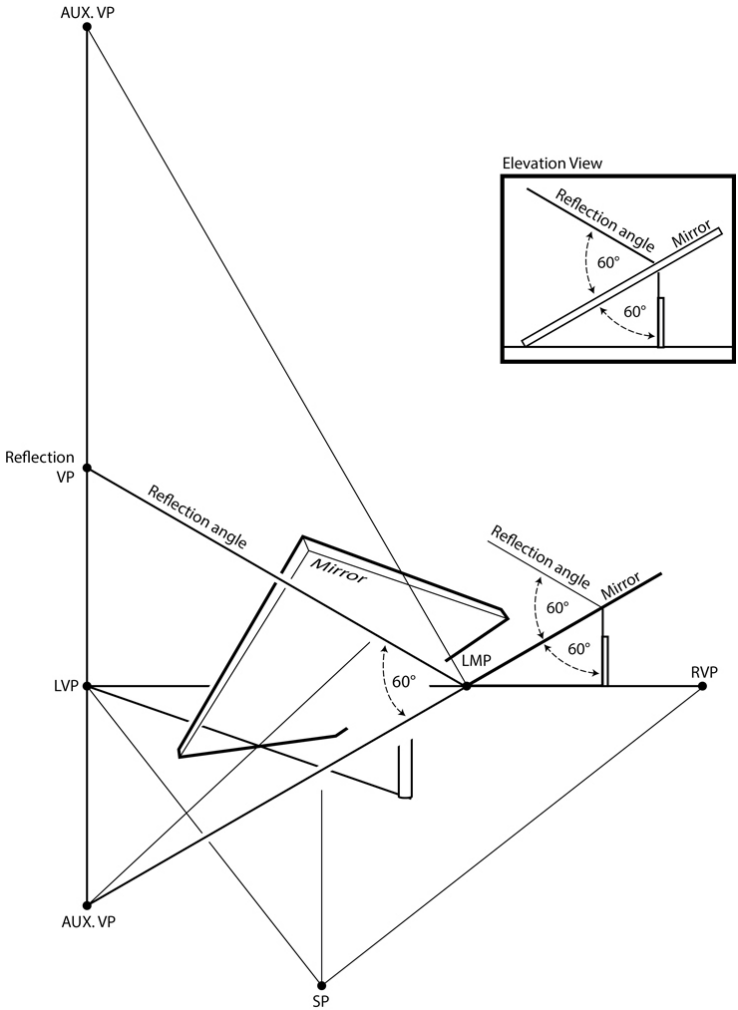


Figure 28.10 Project a 60° angle from the mirror's surface (from the lower auxiliary vanishing point) to establish the reflection vanishing point. **Return to text.**⏎ 356.

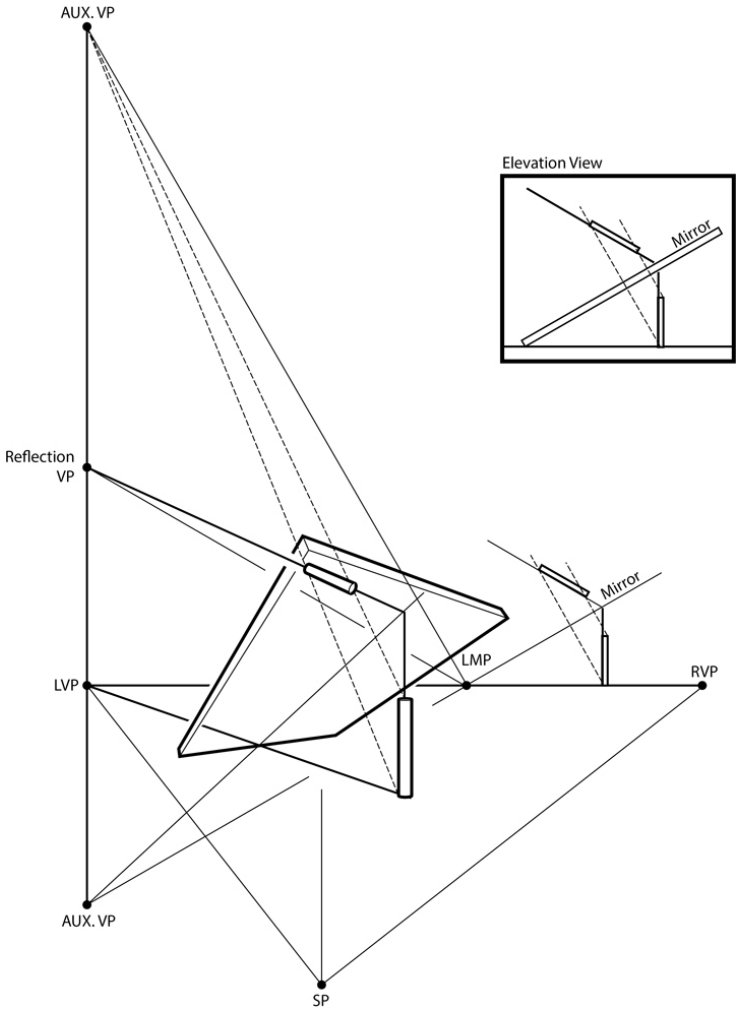


Figure 28.11 Measure the reflection's length by drawing a line from the top and bottom of the object to a point 90° from the mirror's surface (the upper auxiliary vanishing point). **Return to text.**⏎

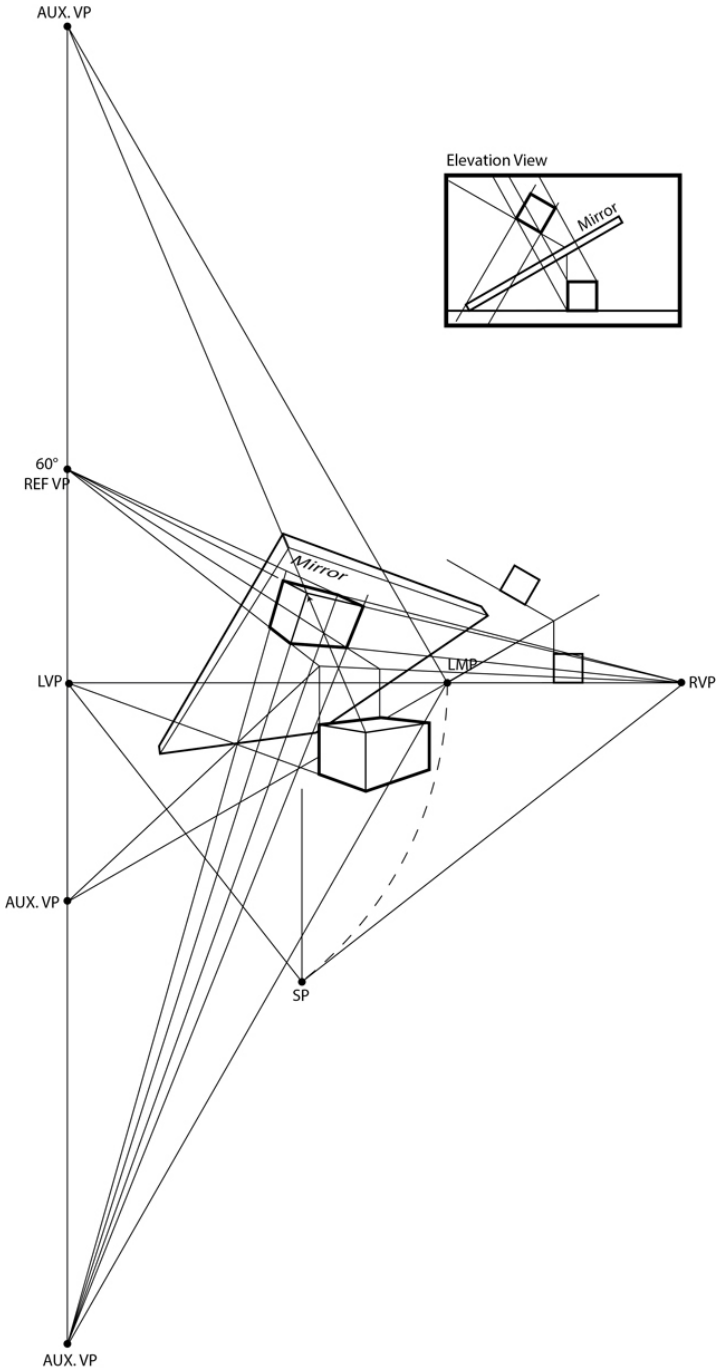


Figure 28.12 This reflection was created using the methods

outlined in the previous illustrations. **Return to text.**⏎

chapter 28
Reflections

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348. While shadows are *on* surfaces, reflections appear *inside* surfaces and appear as a virtual object. Reflections are aligned with the real object, at a right angle to the mirror's surface. The distance from the virtual object to the mirror is the same as the distance from the real object to the mirror. Various methods can be used to plot reflections. The following pages outline a few of the options.

One-Point Perspective

Vertical Mirror (Reflections Along the *y*-Axis)

These reflections have no foreshortening. Measure the distance from the object to the mirror and duplicate that distance inside the mirror. The height of the object does not change (Figure 28.1).

Horizontal Mirror (Reflections Along the *x*-Axis)

Likewise, reflections in a horizontal mirror have no foreshortening. Simply duplicate the object in the reflective surface. If there is distance between the object and the reflective surface, that distance must also be duplicated (Figure 28.2).

Vertical Mirror (Reflections Along the *z*-Axis)

In this scenario, the distance from the object to the mirror is

foreshortened. There are several ways to find a foreshortened distance. A measuring point can be used (Figure 28.3) or a reference point (Figure 28.4). A third method involves using geometry to create two lines of equal length (Figure 28.5). See Figure 38.3 (top) for step-by-step instructions for this procedure.

Two-Point Perspective

Reflections in vertical surfaces are foreshortened. Reflections in horizontal surfaces are not. The same procedures used to plot one-point reflections apply to two-point.

Reflective Angles

All the objects being reflected thus far have been parallel or perpendicular to the reflective surface. If the object is angled to the mirror, the reflection is at that same angle. First calculate the angle of the object to the mirror. Then plot that same angle on the opposing side of the reflective surface (Figure 28.6). Reviewing the information on horizontal angles (Chapter 7) may be helpful.

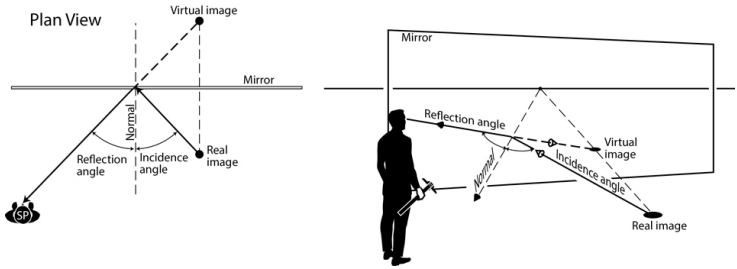
Reflections on Inclined Surfaces

There are many ways to plot reflections in an inclined mirror—any of the previous methods can be used. But understanding how angles work in perspective is the hallmark of becoming a proficient practitioner. So, in the following example, this reflection will be drawn using angles.

In this scenario, the mirror is at a 30° angle to the ground plane (Figure 28.7). First, calculate the angle of the object to the mirror (Figure 28.8). Then duplicate that angle inside the mirror (Figures 28.9–28.10). To establish the length of the reflection, draw a 90° angle to the mirror's surface (Figure 28.11).

357. 358. The reflection of a single line can be complicated. A

three-dimensional object is even more so (Figure 28.12).



359.

Figure 29.1 The law of reflection states that the incidence angle to normal equals the reflection angle to normal. **Return to text.**⏎ 361.

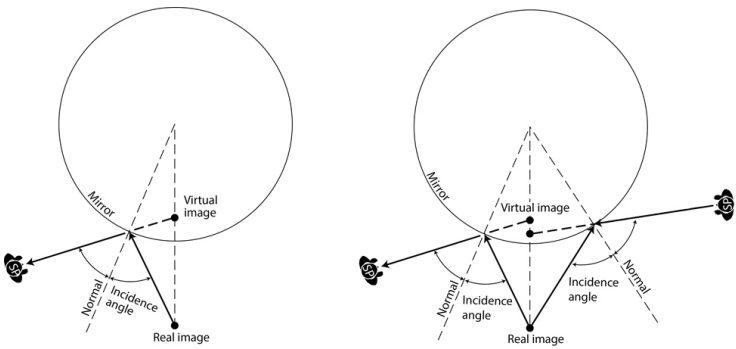


Figure 29.2 The reflection's position inside the convex mirror changes with the viewer's location. **Return to text.**⏎

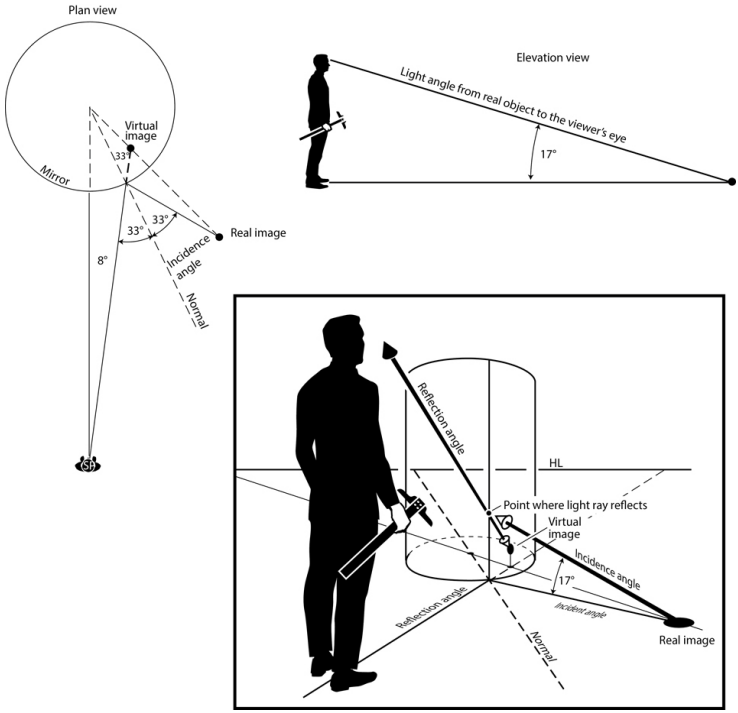
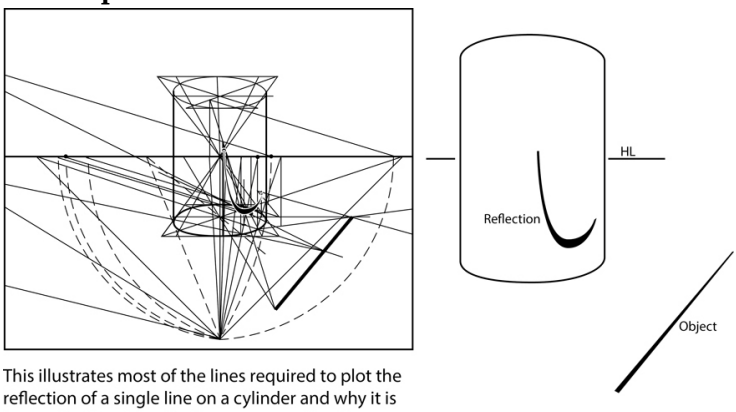


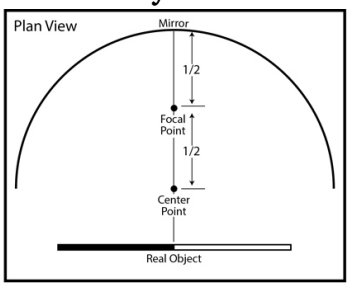
Figure 29.3 To draw a reflection on a cylinder, the angle of incidence and reflection must be plotted, which are at an incline as they travel to the viewer's eye. This is a difficult and impractical task. **Return to text.**⏎



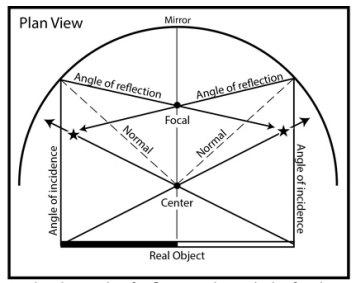
This illustrates most of the lines required to plot the reflection of a single line on a cylinder and why it is impractical to plot reflections on curved surfaces.

Figure 29.4 It was a great deal of work to draw this single reflection. Reflecting an entire environment in a curved surface is an unreasonably difficult task. The drawing on

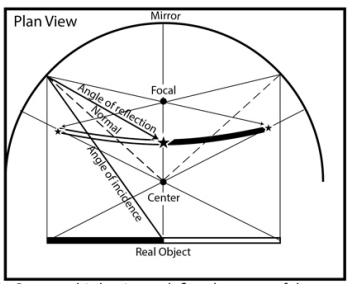
the left is not designed as an instructional guideline but only to illustrate what is needed to plot a single line on a reflective cylinder. **Return to text.**⏎



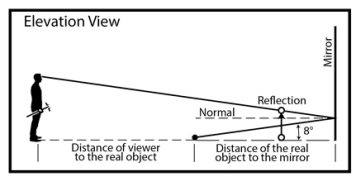
1. The real object is between the center point and the viewer.



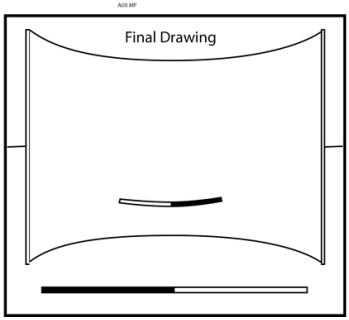
2. Plot the angle of reflection, through the focal point, to locate the reflection's end points.

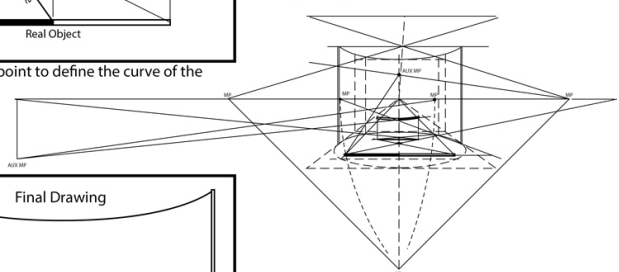


3. Create a third point to define the curve of the reflection.



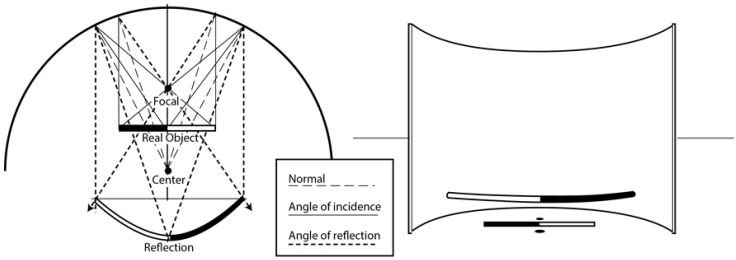
The eye level of viewer must be taken into account when plotting these reflections.



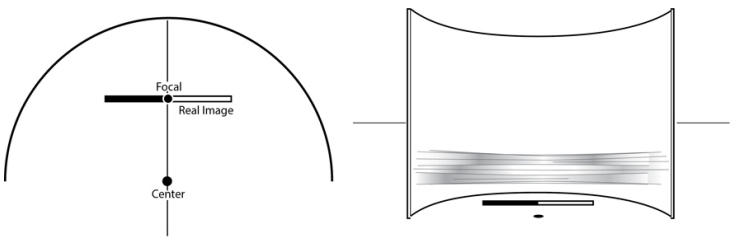


This is not designed to be an instructional illustration, but only to demonstrate the complexity and impracticality of plotting reflections on concave surfaces.

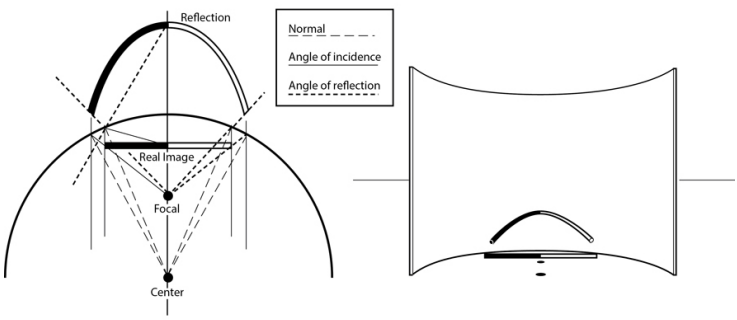
Figure 29.5 Plotting reflections on concave surfaces is difficult and prohibitively time consuming to have a practical application. **Return to text.**⏎ 365.



The real object is between the center and the focal point.
The reflection is reversed, larger than real object, and projected in front of the mirror.



The real object is on the focal point.
There is no reflection, only a blured, streaked image.



The real object is between the focal point and the mirror.
The reflection is not reversed and is projected behind the mirror.

Figure 29.6 Reflections in convex mirrors change dramatically depending on the location of the real object. **Return to text.**⏎ 366. 367.

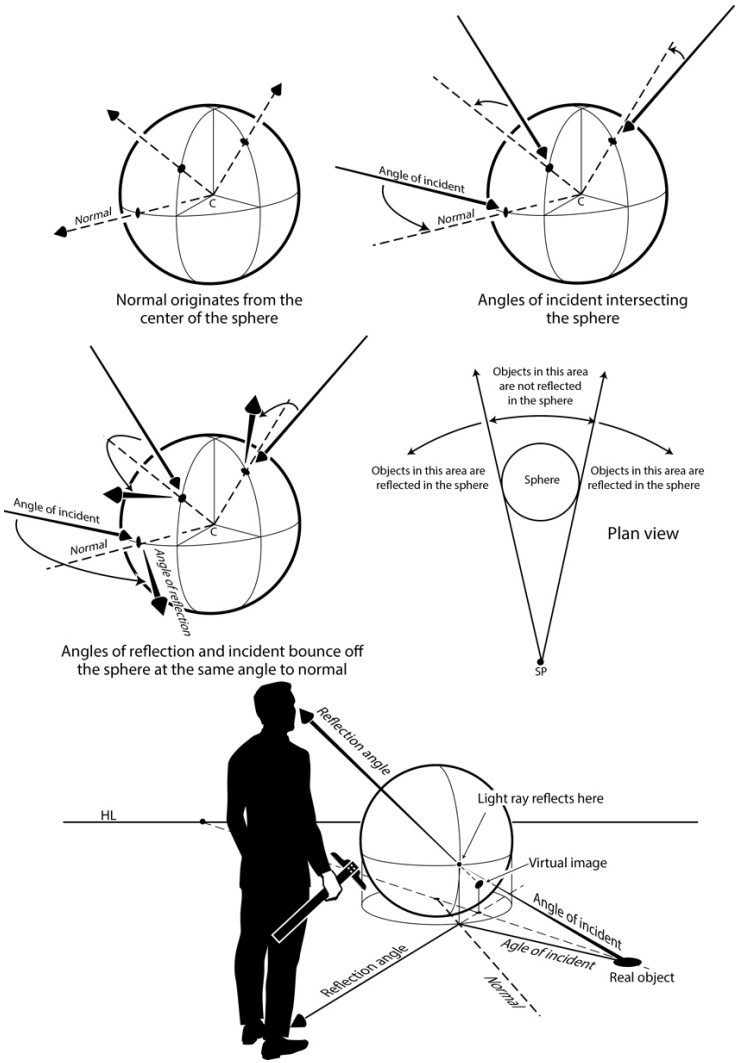


Figure 29.7 Sphere reflections are challenging, to say the least. **Return to text.**⏎ 368.

chapter 29
Reflections on Curved Surfaces

DOI: 10.4324/9781003488101-39

360. Reflections on curved surfaces is rarely discussed. The subject is usually ignored, or the advice is to "just fake it." This can be troublesome, so this subject will be explored further. But before looking at reflections on curved surfaces, reflections on flat planes will be reviewed first.

Reflections are seen when light waves bounce off shiny surfaces. The wave's angle is key to the perceived position of the reflected image. Reflections appear to be inside the mirror. There is, of course, no object inside the mirror. So why is an object seen where none exists?

First, consider the science behind reflections. An angle 90° from a reflective surface is called "normal." Light rays hit reflective surfaces at specific angles to normal. This angle is called the incidence angle. The reflective light angle is always the same to normal as the angle of incidence (Figure 29.1). To put it simply: light bounces off a surface at the same angle it hits the surface. This is the law of reflection.

So, light is bouncing off the surface, but light is seen as a straight line. Because of this, two images are seen: the real object and a virtual object (the reflection). The reflection is seen aligned with the reflection angle. In flat mirrors, reflections appear to be inside the mirror. The reflection appears at the same distance from the reflective surface as the real object (Figure 29.1).

Convex Surfaces

The law of reflection works the same with curved surfaces. But the position of the reflection is different than those on flat surfaces. The reflection's position changes with the position of the viewer. The distance from the real image to the mirror can't be measured and duplicated. This makes plotting a reflection *much* more difficult (Figure 29.2). To complicate matters, a cylinder reflects beyond 180°. Depending on the angle of

incidence, objects behind the cylinder may be reflected (these reflections are thin slivers seen at the edge of the cylinder).

362. To draw reflections on a cylinder, the incidence angle to normal needs to be plotted for each object. Although this is possible, it is impractical. While it may be attempted for "fun," it will also take a long time. Only a few points need to be plotted to understand how these reflections work (Figures 29.3–29.4). Likewise, only a few points need to be plotted to appreciate how time-consuming this exercise is.

363. 364. So, if it is not practical to plot reflections on curved surfaces, how are they approached? First, develop a solid understanding of the geometry. Understand the relationship between the viewer, the incidence angle, and the virtual image. Knowledge is the best tool. In addition, have at hand a collection of curved reflective objects. Metallic paper can be purchased at most art stores and bent into many different shapes. Seeing the actual reflections brings the science to life. With an understanding of the science, and a collection of reflective objects to refer to, intelligent and convincing reflection estimations can be made.

Concave Surfaces

There is a subject even more difficult than convex surfaces: concave surfaces. Fortunately, reflective concave surfaces are not common; they will be briefly addressed, nonetheless. To fully cover the complexity of this topic would require more space than is available, so here is an overview.

Concave surfaces have a center point (the center of the reflective surface's arc) and a focus point (a point halfway between the center point and the mirror) (Figure 29.5, upper left). While the rule governing the angle of incidence and angle of reflection to normal still applies, the angle of reflection always passes through the focus point (Figure 29.5, upper right).

Four examples of reflections on concave surfaces are presented. The reflections are quite different depending on the

position of the object being reflected. Sometimes the reflection is reversed; sometimes it is upright.

Reflections of objects between the viewer and the center point appear smaller, reversed, and in front of the mirror (Figure 29.5).

Reflections of objects between the focus point and center point appear larger, reversed, and in front of the real object (Figure 29.6 top).

Objects at the focus point disappear—in theory. In reality, the reflection looks like a blurred streak across the mirror surface (Figure 29.6 middle).

Objects between the focus point and the mirror are larger, not reversed, and appear behind the mirror (Figure 29.6 bottom).

The usual advice for drawing reflections on curved surfaces is to "just fake it." But if this is not understood, then the results will be far from convincing. This is not to say that plotting reflections on curved surfaces is advocated; it is extremely difficult and time consuming. The previous information was designed to give a basic understanding of the underlying science so it *can* be faked with confidence. Approximations should be based on educated estimations, not on random guesses.

Again, it is helpful to purchase a piece of reflective paper. This paper can be manipulated to create a variety of curved shapes, which can be a valuable reference tool.

Sphere

Plotting reflections on a sphere requires the same tedious process. The rules of reflection still apply. Reflections on curved surfaces can be plotted by hand—but it is not recommended (Figure 29.7). Like convex and concave surfaces, the process is prohibitively time consuming. It is best to find a reflective sphere to use as reference. An understanding of the science is of equal importance; knowledge is empowering.

Most books ignore the topic of reflections on curved surfaces. As demonstrated, the reason is that they are difficult and time

consuming. The best advice is to understand the science. Knowledge is empowering—just *knowing* may be enough.

369. 370.

part eleven
Anamorphic Perspective

371.

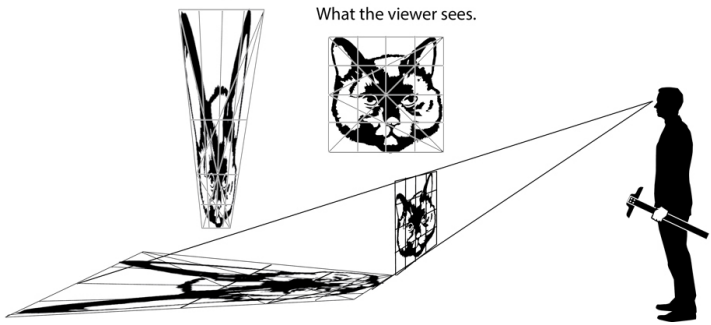


Figure 30.1 The anamorphic image comes into focus when seen from the proper point of view. **Return to text.**⏎

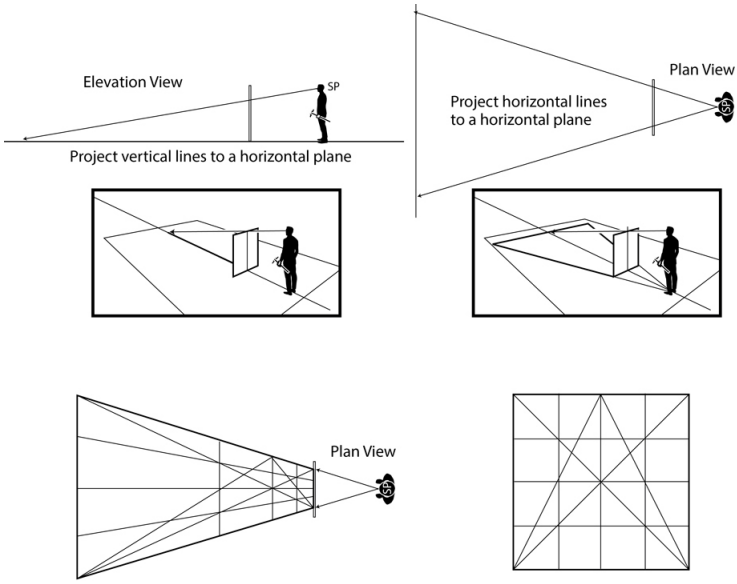
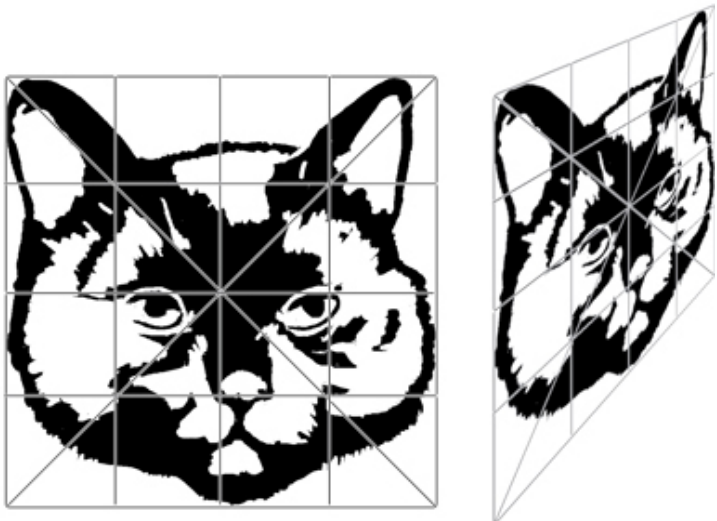


Figure 30.2 Plotting an anamorphic grid. **Return to text.**⏎ 373.



374.
Figure 30.3 To draw a foreshortened image, draw a foreshortened grid. Be sure to adjust the thickness of the lines; they are foreshortened as well. **Return to text.**⏎

chapter 30
Anamorphic Perspective

DOI: 10.4324/9781003488101-41

372. Anamorphic images came about early in the development of perspective. Artists such as Piero della Francesca and Leonardo da Vinci experimented with solutions to correct for the distortion caused when looking obliquely at church frescos. As the congregation looked up at the frescos, the nearby feet looked exceptionally large compared to the distant heads (Chapter 2, Figure 2.4). A solution to this problem was quickly formulated. The desired image was projected on the wall using

a grid. This projected image corrected the distortion. Anamorphosis is the process of projecting a flat image on an oblique surface. Looking at this projected image from an angle other than the one it was projected from, results in a distorted drawing—often to the point of non-recognition. But the image comes into focus when seen from the location it was projected from. Street artists use this technique with amusing effects in sidewalk chalk festivals.

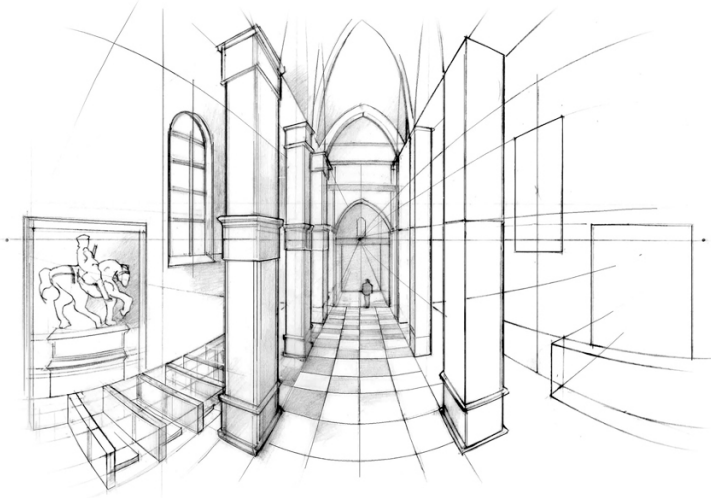
Beyond its practical use, anamorphosis is sometimes used as an entertaining trick. An artist creates a mysterious skewed image; the viewer must then find the vantage point that reveals the picture (Figures 30.1–30.2)

Foreshortened Image

On a related subject, this technology can be used to depict a flat image on a foreshortened surface. For example, if drawing a picture hanging on a wall, and this picture were foreshortened, this same procedure could be used in reverse. Instead of the final image being stretched, it is compressed. First put a grid on the picture being drawn, and then draw that same grid in perspective. Use the grid as a guide to plot points (Figure 30.3).

375. 376.

part twelve
Curvilinear Perspective



377.

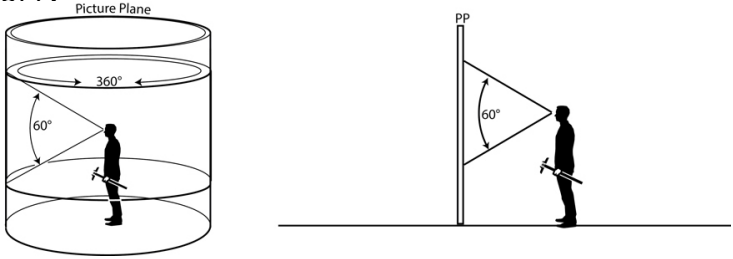


Figure 31.1 The picture plane is cylindrical in four-point perspective. **Return to text.**⏎ 379.

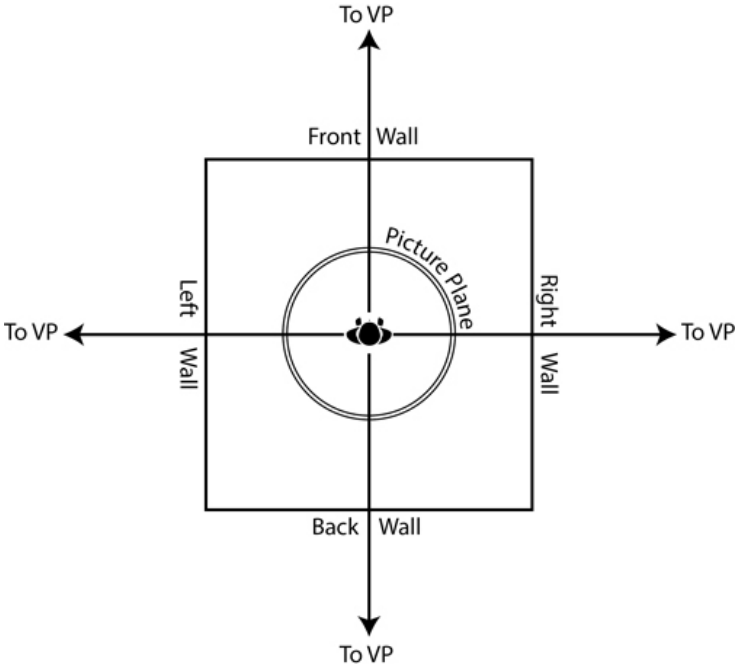
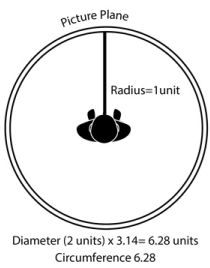
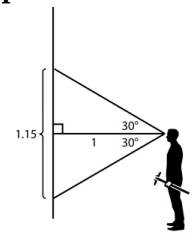


Figure 31.2 A plan view showing the viewer, the picture plane, the room, and the four vanishing points. **Return to text.**⏎





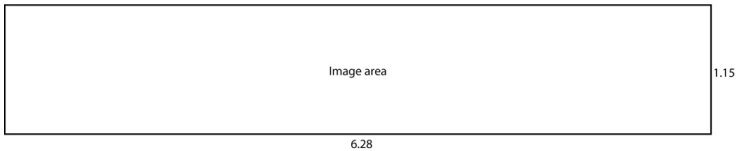


Figure 31.3 Calculating the length and height of the panorama. The image area of a four-point diagram is roughly a 1:6 ratio. **Return to text.**⏎ 380. 381.

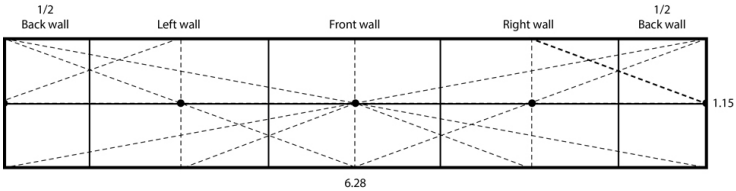


Figure 31.4 Divide into quadrants to find the four walls. Use a ruler or draw an X to divide by half. Add vanishing points centered in each wall. **Return to text.**⏎

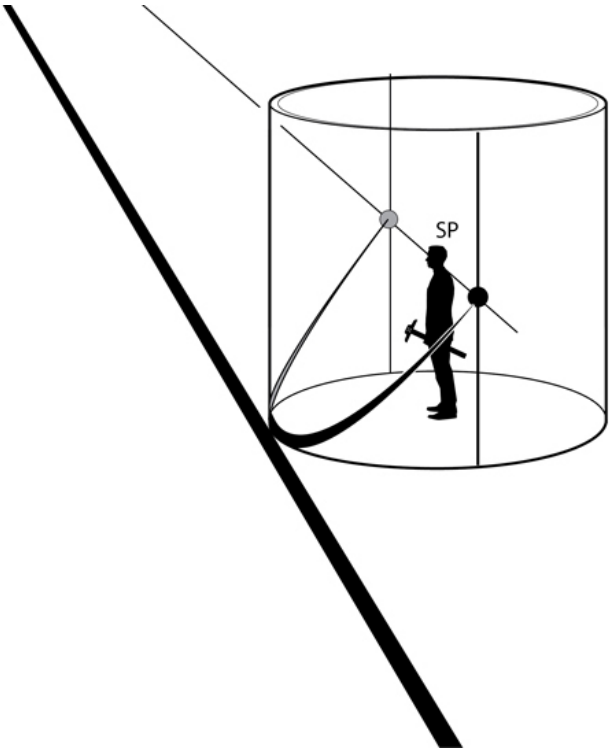


Figure 31.5 An infinite horizontal line traced on a cylindrical picture plane creates a sinusoid. **Return to text.**⏎

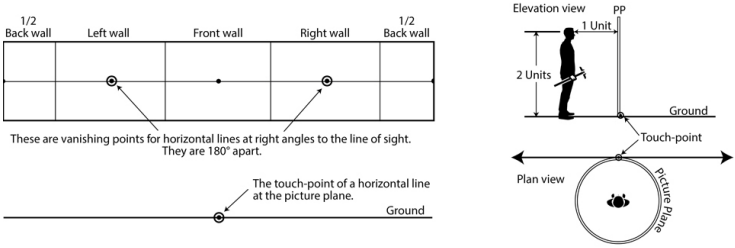


Figure 31.6 The first three points of the sinusoid are the “easy”

ones to locate. Return to text.

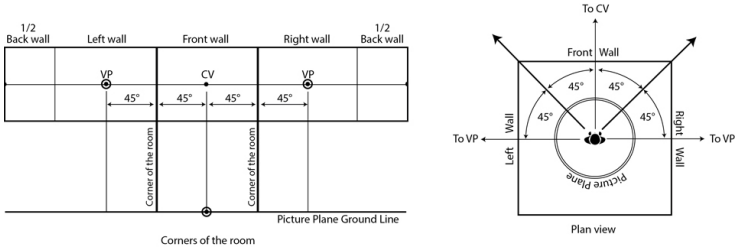
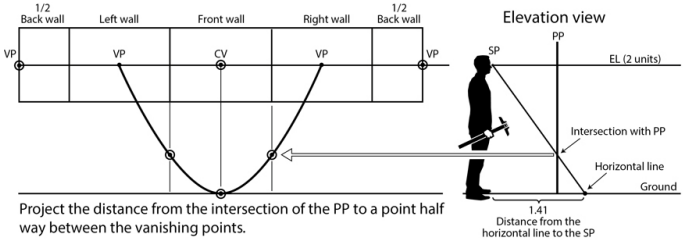
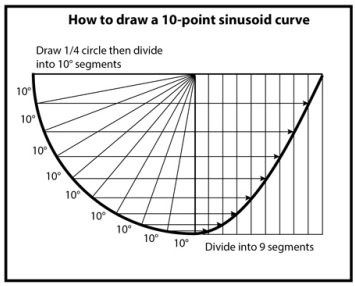
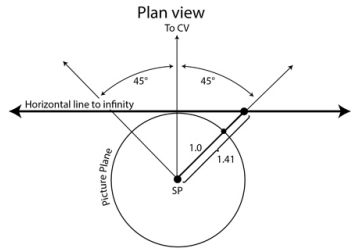


Figure 31.7 Because the room is a square, the corners are 45° from the station point. Return to text.







The distance from the station point to the picture plane is 1 unit. The distance from the station point to the horizontal line is 1.41 units.

Figure 31.8 To plot an accurate curve, the more points the better. Three points are a minimum for half the curve, and for our purposes that will often suffice. Return to text.

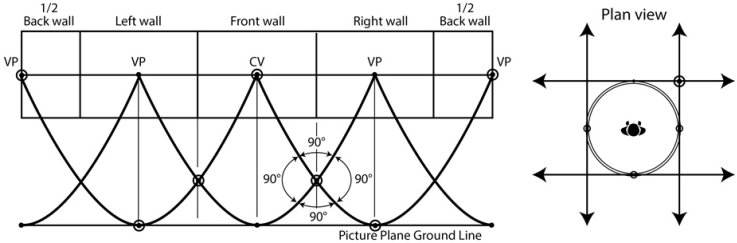
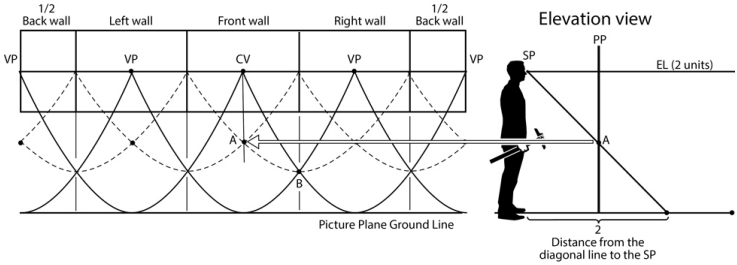
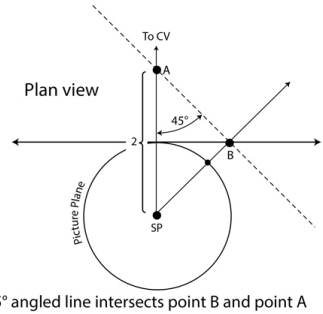


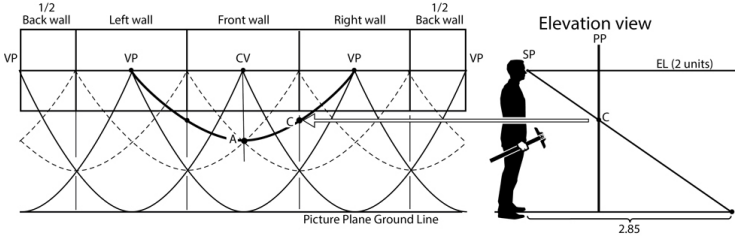
Figure 31.9 Copy and repeat the lines, creating four orthogonal lines of infinite length. Return to text.

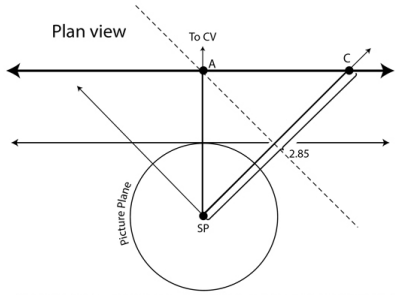




A 45° angled line intersects point B and point A

Figure 31.10 Plot a 45° angle using the procedure outlined in Figure 35.8. **Return to text.**⏎





The distance from the station point to intersection C is 2.85 units.

Figure 31.11 Repeat the process to plot an additional horizontal line. **Return to text.**⏎

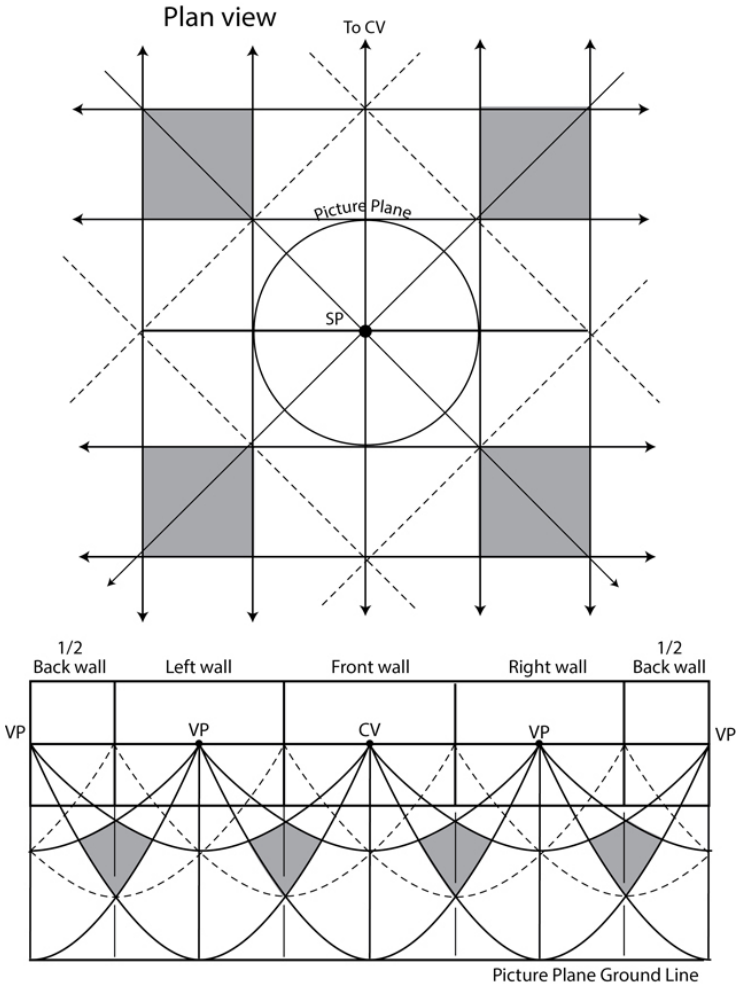


Figure 31.12 Copy and repeat the curves to make a grid. **Return to text.**

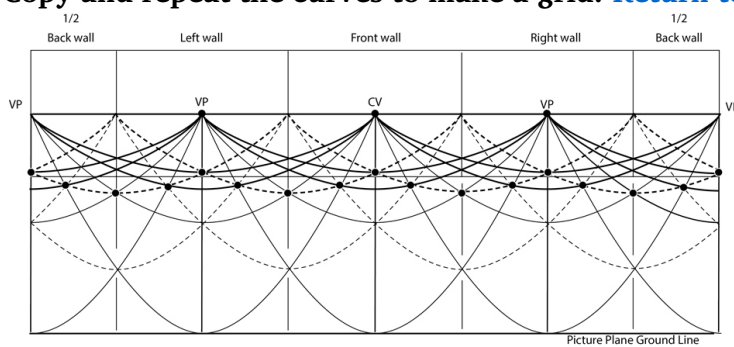


Figure 31.13 Continue to copy and repeat the curves,

finding intersections to create a grid. Return to text.⏎

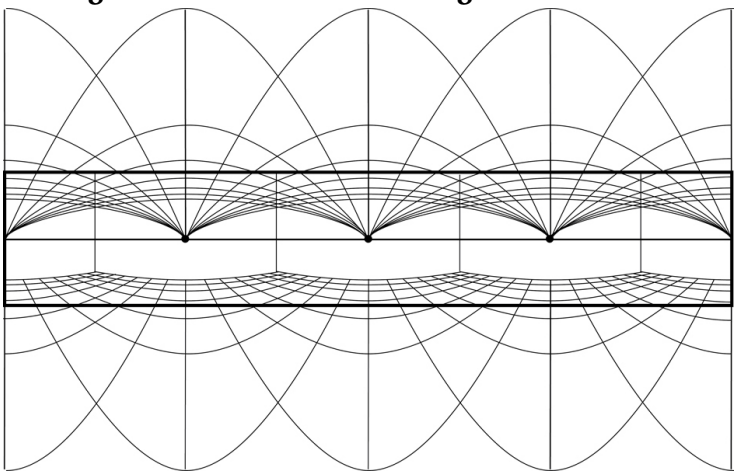


Figure 31.14 The ceiling is a mirror image of the floor. Return to text.⏎ 388.

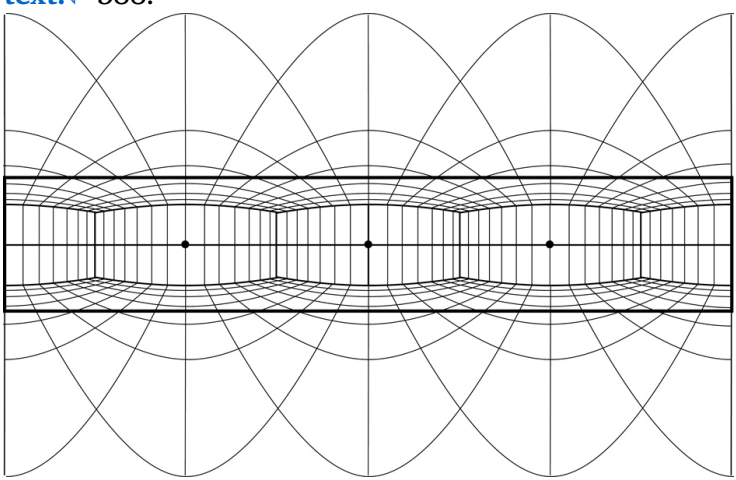
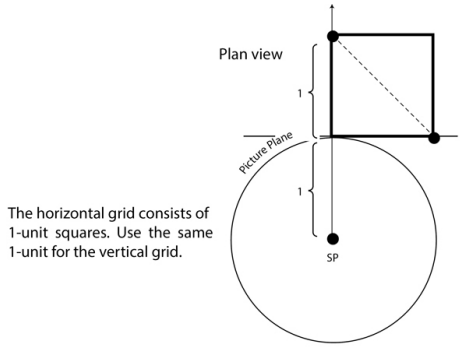


Figure 31.15 Crop the image and draw vertical lines on the walls where horizontal lines intersect. Return to text.⏎



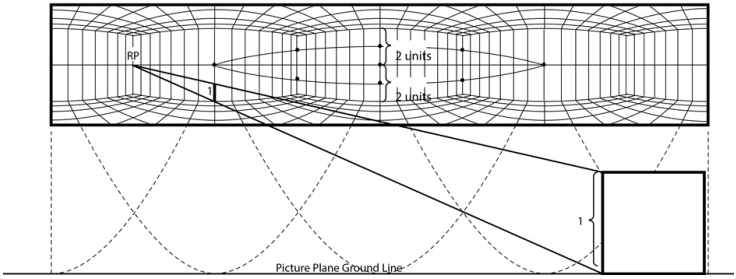


Figure 31.16 The eye level is 2 units above the ground. Divide the center line into four even segments, creating a horizontal grid. **Return to text.**⏎ 389.

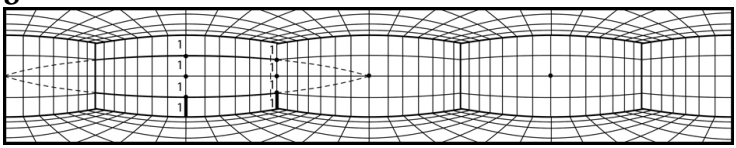


Figure 31.17 The completed grid. **Return to text.**⏎ 390.

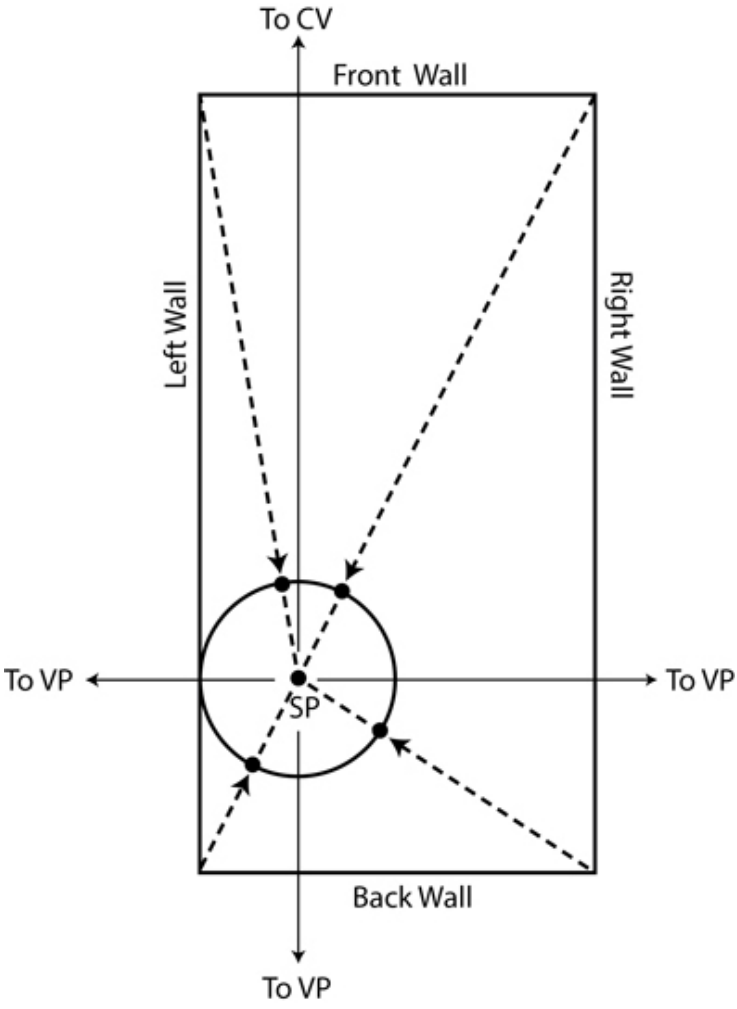


Figure 31.18 Project the width of each wall to the picture plane.
Return to text.⏎

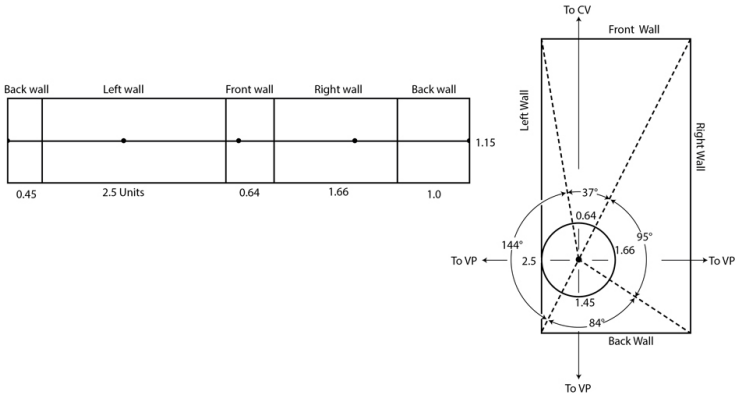
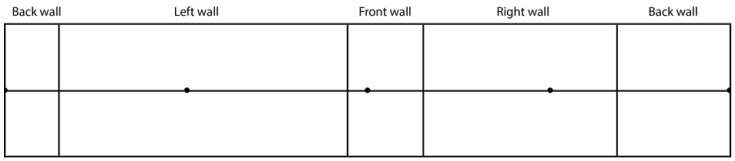
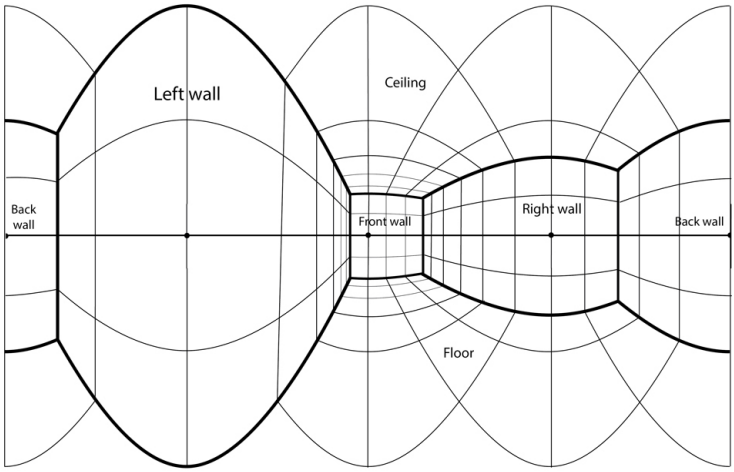
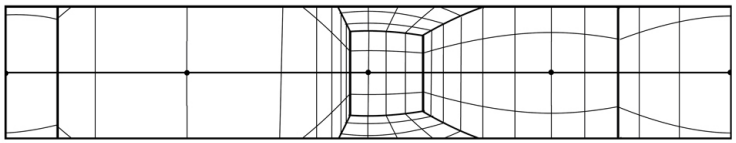


Figure 31.19 Plot the walls and vanishing point locations. [Return to text.](#)







Cropped to cone of vision

Figure 31.20 This grid was drawn by the same process used in

Figures 35.6–35.18. The left wall is touching the picture plane, and the front wall is the farthest from the viewer. **Return to text.**⏎ 391.

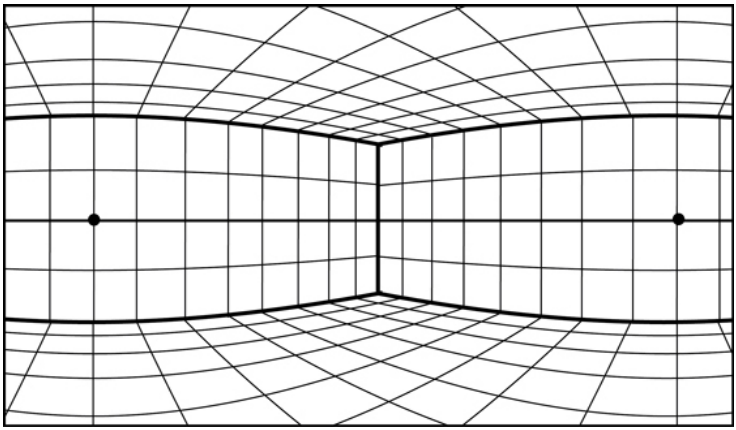
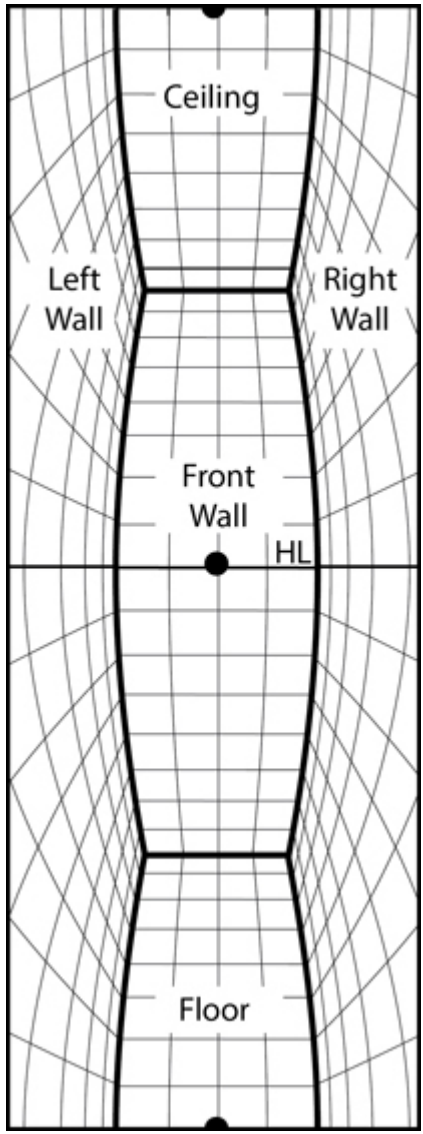


Figure 31.21 This is a four-point perspective view, cropped a little beyond 90° (the two vanishing points are 90° apart). **Return**



to text.⏎ **Figure 31.22 A vertical four-point perspective view cropped at 180˚. Beyond 180˚, the image is inverted.** Return to text.⏎

chapter 31

Four-Point Perspective

DOI: 10.4324/9781003488101-43

378. Objects not aligned with the center of vision become distorted. The farther they are from the center of vision, the more distorted they become. Distortion occurs when the visual pyramid intersects the picture plane at an oblique angle. The more aslant the angle, the greater the distortion. But what if the picture plane is not flat? What if the picture plane is curved? The picture plane, after all, does not *need* to be flat. If the picture plane is cylindrical, the intersection of the visual pyramid will be at a right angle. The viewer's eye is at the center of the cylinder. Any line connecting to the station point will intersect the picture plane at a 90° angle to its surface. If the cylinder fully surrounds the viewer, a 360° panoramic view can be drawn without the extreme distortion caused by a flat picture plane.

Using a curved picture plane still creates distortion; it is just a different kind of distortion. With a curved picture plane, horizontal lines appear curved in the final drawing. Vertical lines, however, are parallel to the picture plane and are drawn as straight lines.

The picture plane, being circular, gives a 360° image area horizontally. But, because the walls are flat, the standard 60° cone of vision still applies to the vertical axis (Figure 31.1).

Four-Point Perspective Components

Vanishing Points

There are four vanishing points, each 90° apart: one at the center of vision, one 90° to the right, one 90° to the left, and one directly behind the viewer. Objects that are at different angles will use different vanishing points.

To illustrate how these vanishing points function, draw a

symmetrical room with the viewer placed in the center. A vanishing point is centered on each wall (Figure 31.2).

Image Area

The picture plane is cylindrical, but the drawing surface is two-dimensional. So, the first step is to flatten the picture plane. The image area will be 360° long and 60° high.

Length

To calculate the length, the circumference of the picture plane must be known. This is a simple formula: multiply the diameter by pi (π). To do this, measure the distance from the station point to the picture plane (the radius). Multiply the radius by 2 (the diameter). Then multiply the diameter by 3.14 (pi). The circumference of the picture plane is the length of the panorama (Figure 31.3).

Height

The height of the panorama remains 60° from the station point. Use the Pythagorean theorem to find the height. Or draw an elevation view (to scale), with a 60° cone of vision, and measure the height with a ruler (Figure 31.3, top right).

Considering that the cone of vision is not an exact degree to be observed, rounding off the image to a 1:6 (height to length) proportion can save some time. Just decide how high you want the image to be, then multiply that by 6 to get the length. You then have your image area.

The Drawing

The viewer is in the center of a square room. This means the walls are equally spaced and the drawing can be divided into four even quadrants. Each quadrant represents the width on the wall. Then, place a vanishing point in the center of each wall (Figure 31.4).

Horizontal Lines

Imagine a horizontal line of infinite length, at a right angle to the line of sight. This line would disappear at the vanishing points that are 90° to the right and left of the center of vision. If this line were on the ground and traced on the picture plane, it would curve up to connect with the vanishing points (Figure 31.5). Lines above the eye level would curve down. These curves are not simple compass arcs—that would be too easy. They are a sinusoid.

382. To plot this curve, the viewer's eye level must be known (2 units above the ground) and how far the viewer is from the picture plane (1 unit) (Figure 31.6).

This line connects to the right and left vanishing points and touches the picture plane at the ground level. This gives three known points (Figure 31.6).

These three points can be connected to draw an arc, but three points are not enough to draw an accurate shape. At least two more points are needed.

Place these additional two points 45° on each side of the center of vision. Since the room is square, they will be aligned with the room's corner (Figure 31.7).

383. The points that are needed indicate the distance from the line being drawn to the picture plane. This distance must be plotted. This can be accomplished using the Pythagorean theorem, but there is also a longhand method that does not require math. Draw a plan view to scale. Measure the distance from the station point to the picture plane and the distance from the station point to the line being drawn (Figure 31.8, bottom right). Transfer those dimensions to an elevation view drawn to the same scale; then project the distance to the picture plane (Figure 31.8, top right). Transfer that distance to the four-point diagram. Now there are five points available to plot the curve. Connect the points to draw a sinusoid (Figure 31.8 top left). I like using this approach to draw the curve because it explains the sinusoid shape in the context of a perspective diagram. A more common approach is to draw a ten-point

sinusoid (Figure 31.8 bottom left). You can use fewer points if you like.

384. Copy and repeat the curves, connecting each to vanishing points. The intersection of the lines creates a 90° corner (Figure 31.9).

Create new sinusoids with a shorter amplitude by finding two new points along the curve (Figure 31.10, A and B). These sinusoids are at a 45° angle to those that connect to the vanishing points. These 45° angles will assist in creating a grid of four-point perspective squares.

385. Create an additional sinusoid behind the first, using the same procedure (Figure 31.11).

386. Copy and repeat the sinusoids to create a series of squares (Figure 31.12).

387. Continue to copy and repeat until the four-point perspective grid is complete (Figure 31.13).

Much of the grid that has been drawn is outside the cone of vision, outside of the 60° vertical limit. That part of the grid is distorted beyond what is acceptable and needs to be cropped (Figure 31.14). Some enjoy the distorted look and extend the cropping beyond the 60°.

Vertical Lines

Vertical lines are parallel to the picture plane and are drawn as true verticals (Figure 31.15). Measure vertical lines as measured in one- or two-point perspective. Measure up from the picture plane and project the height to the desired location. It is not necessary to use a sinusoid to transfer vertical lengths (Figure 31.16).

Finalize the grid by connecting lines to vanishing points (Figures 31.17).

Creating a four-point grid is not an easy or quick task. To expedite the job, many illustrators eyeball the sinusoid and estimate dimensions. This is not the most accurate approach, but it does save a great deal of time. Understanding how to do it accurately would surely benefit any freeform approach.

As complicated as this diagram is, it is simpler than a diagram where the viewer is not in the center of the room and the room is not a square. In this scenario, the image can't be divided into four even spaces. The length of each wall must be plotted separately.

Length

In this example, the room is rectangular. To plot the length of each wall, start with a plan view. Project the length of each wall to the station point, intersecting the picture plane (Figure 31.18). The picture plane is cylindrical so approach width in terms of degrees.

The length of each wall is represented on the picture plane as an arc, a section of a circle. To find the length of each wall, the length of each arc must be calculated (Figure 31.19). This next step requires a little math. The formula to measure the length of an arc is $2\pi R\ (C/360)$ where:

C is the central angle of the arc in degrees
R is the radius of the arc
π is 3.14.

There are several websites that offer calculators to solve this problem (search for: arc length circle calculator).

Unlike the previous drawing, the vanishing points are not centered within each wall. Each is still 90° apart and plotted using the same methods as Figure 35.4. The grid for this asymmetrical room was drawn using the same method as the previous symmetrical room (Figure 31.20). Using this method, any environment can be accurately created and measured in four-point perspective.

392. It should be noted that a 360° image is so foreign to the viewer's eyes that it is difficult for the brain to process. To create a more pleasing and comprehensible picture, it is worth cropping the image area, keeping the view within 180° (Figure 31.21).

Vertical Four-Point

A four-point diagram turned sideways creates a vertical panorama. It combines a bird's-eye view with a worm's-eye view. The view includes what is below, in front, and above. This includes the floor, the wall facing the viewer, and the ceiling above them. Vertical lines extend to vertical vanishing points: one at zenith and one at nadir. Horizontally, however, the field of vision remains at 60° (Figure 31.22).

393.

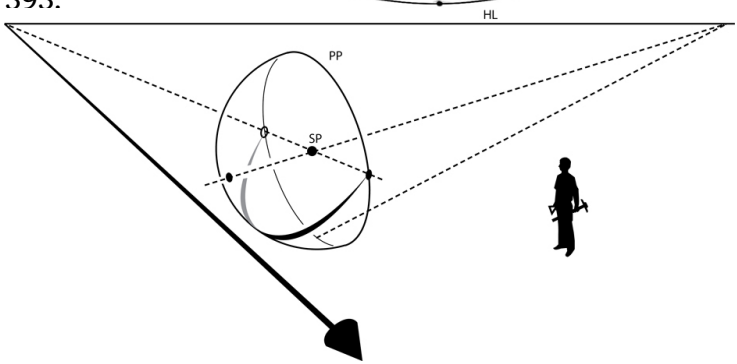


Figure 32.1 Horizontal lines projected on a hemisphere connect to vanishing points on horizon line 90° from the center of vision. **Return to text.**⏎ 395.

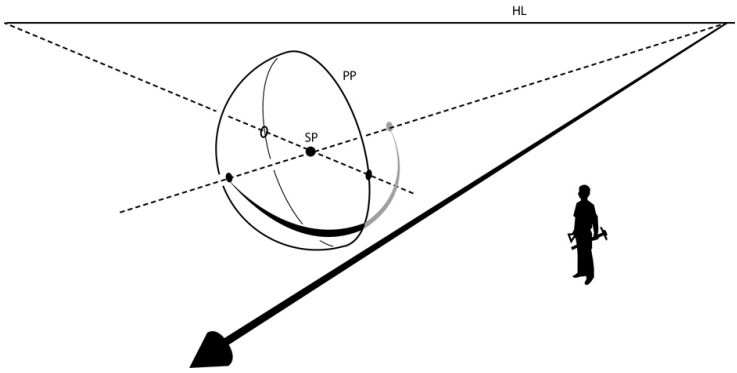


Figure 32.2 Horizontal lines projected on a hemisphere are a half a great circle, one vanishing point being the center of vision and the other behind the viewer (not shown). **Return to text.**⏎

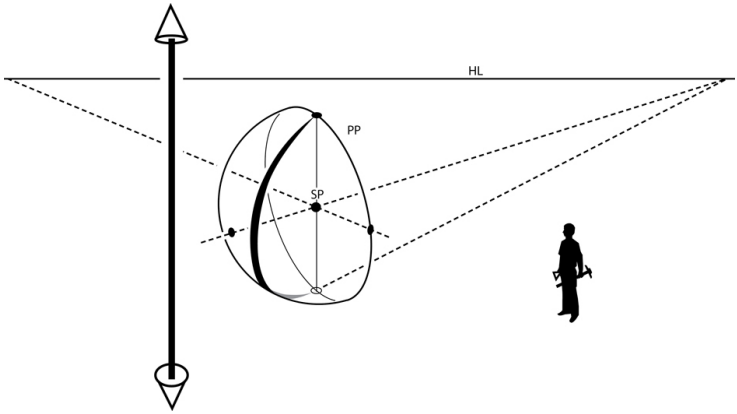


Figure 32.3 Vertical lines projected on a hemisphere are a great circle, with vanishing points at the top and bottom of the picture plane. **Return to text.**⏎ 396.

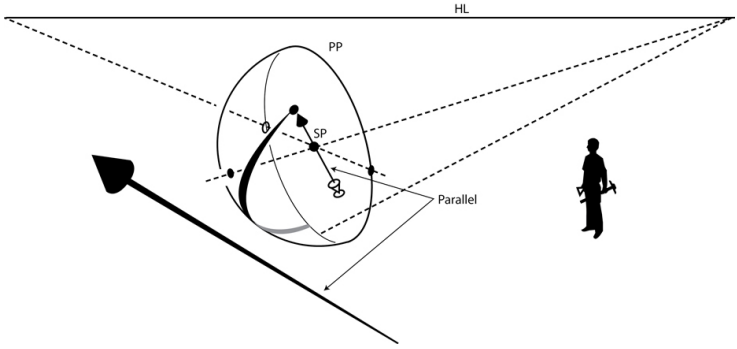


Figure 32.4 The vanishing points for angled lines are at the same

angle as the line being drawn, with vanishing points 180° apart. Return to text.⏎ 397.

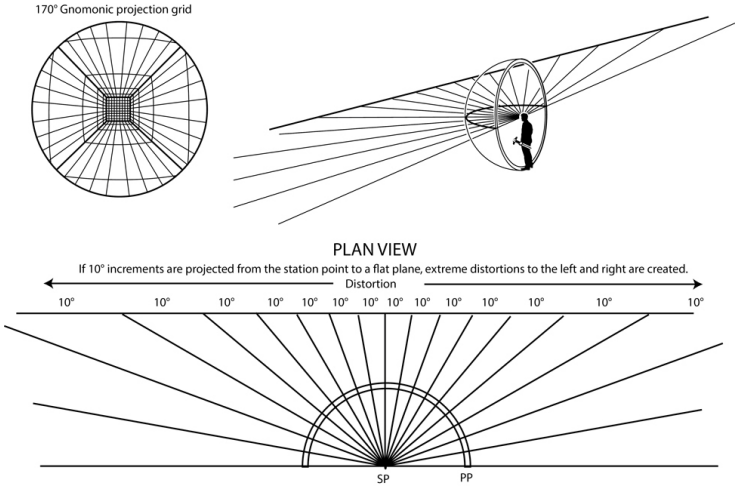


Figure 32.5 Gnomonic projection. Return to text.⏎ 398.

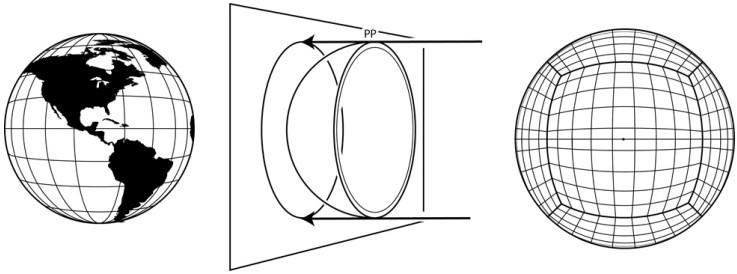


Figure 32.6 Orthographic projection. Return to text.⏎

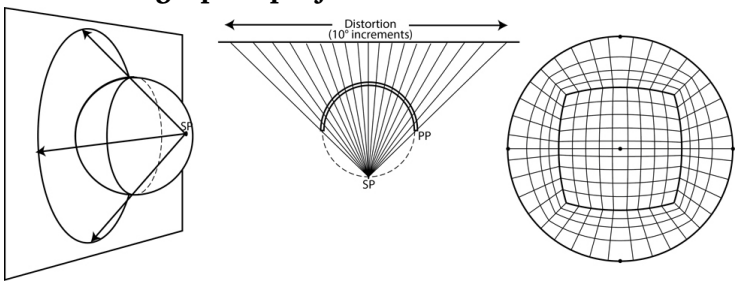


Figure 32.7 Stereographic projection. Return to text.⏎ 399.

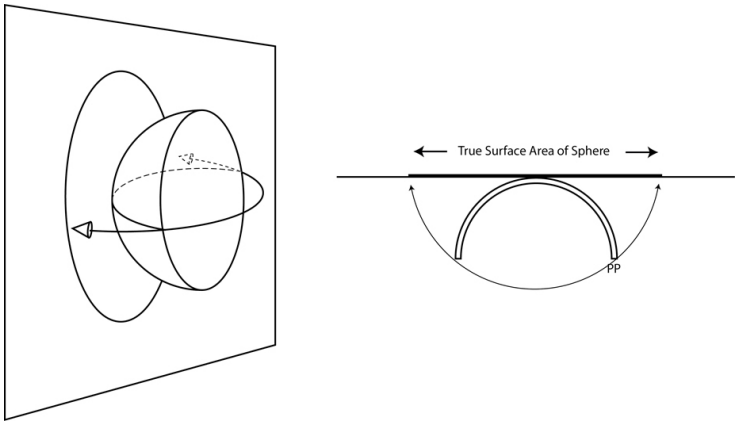
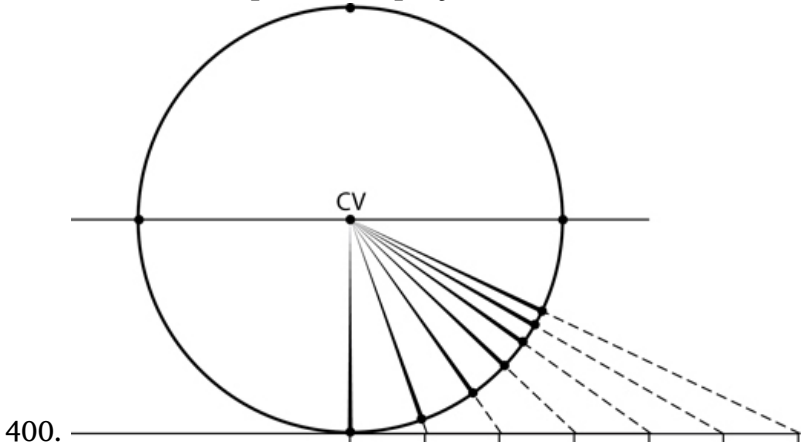


Figure 32.8 Azimuthal equidistant projection. **Return to text.**⏎



400.

Figure 32.9 Evenly spaced horizontal lines projected to the hemisphere, then connected to the center of vision. **Return to text.**⏎

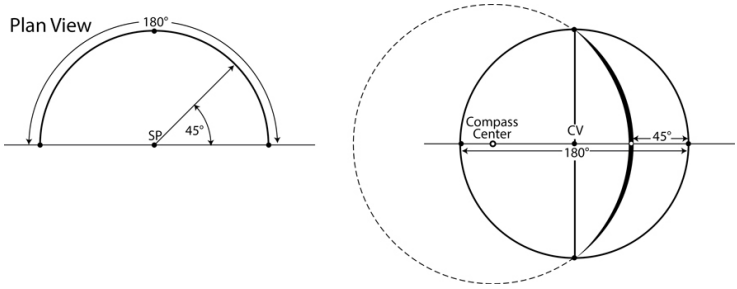


Figure 32.10 A vertical line 45° to the right of the center of vision. **Return to text.**⏎ 401.

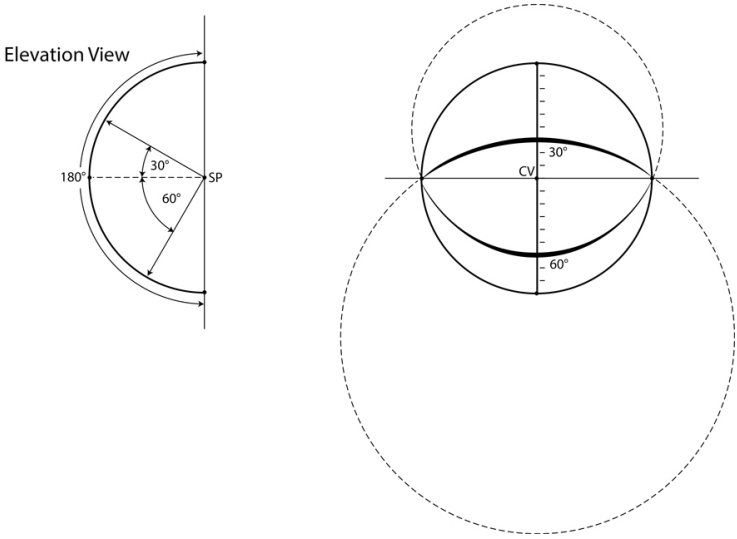


Figure 32.11 Placement of horizontal lines are determined in degrees. The drawing above illustrates a horizontal line 30° above the horizon and a horizontal line 60° below the horizon. **Return to text.**⏎ 402.

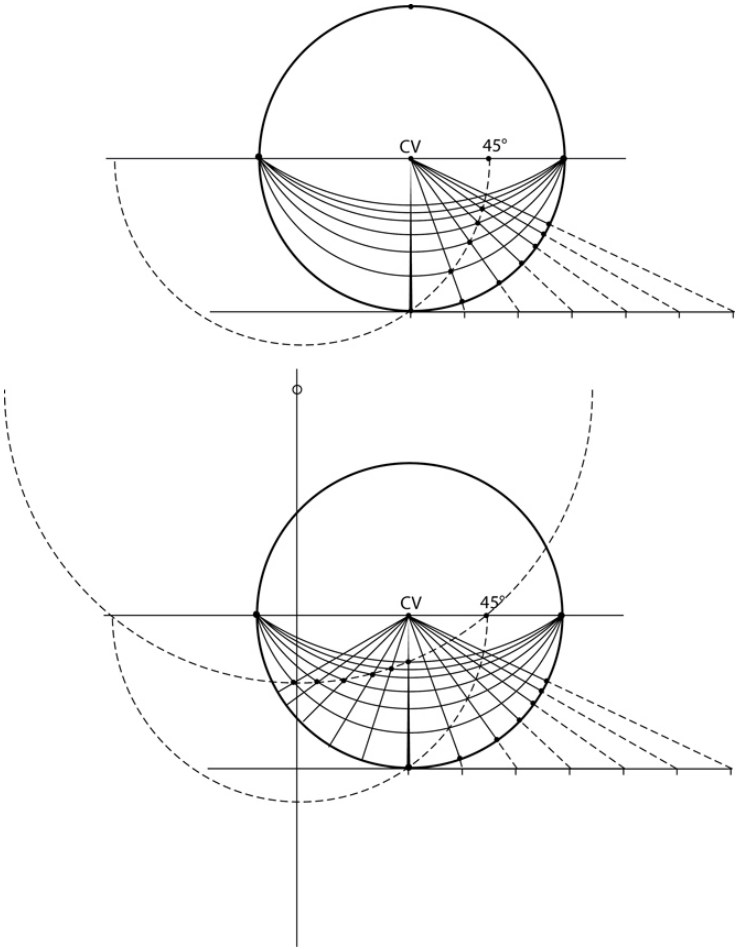


Figure 32.12 Create a series of squares using the 45° vanishing point. **Return to text.**⏎

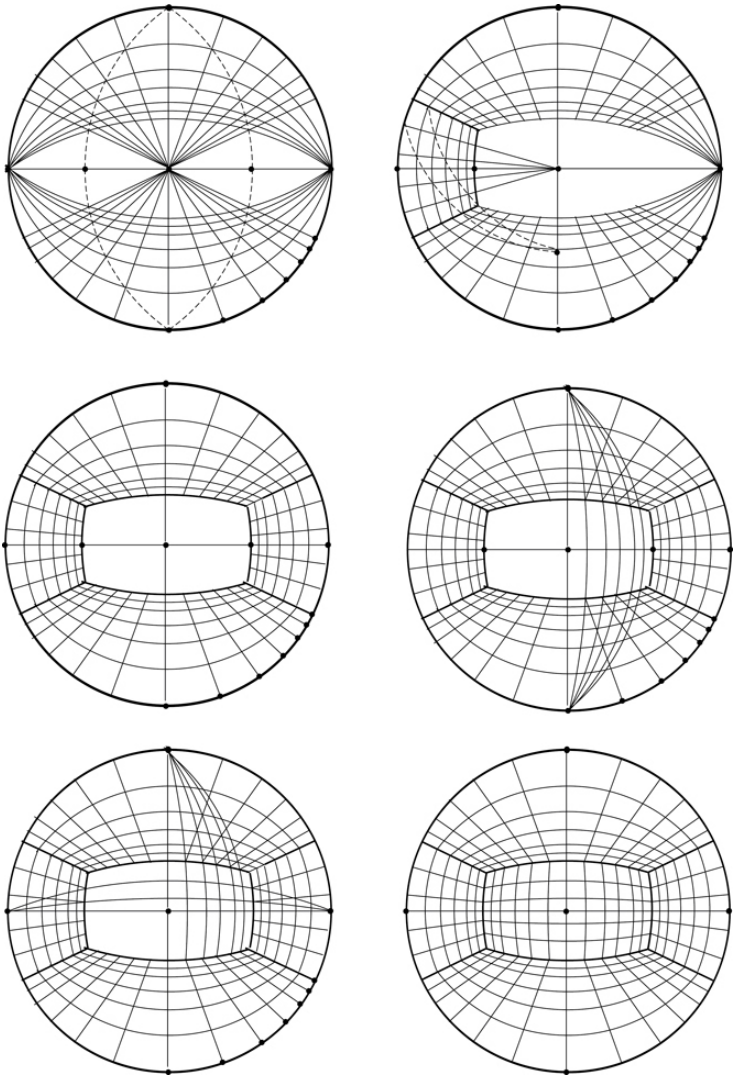


Figure 32.13 Repeat the process to complete the grid. **Return to text.**⏎ 403.

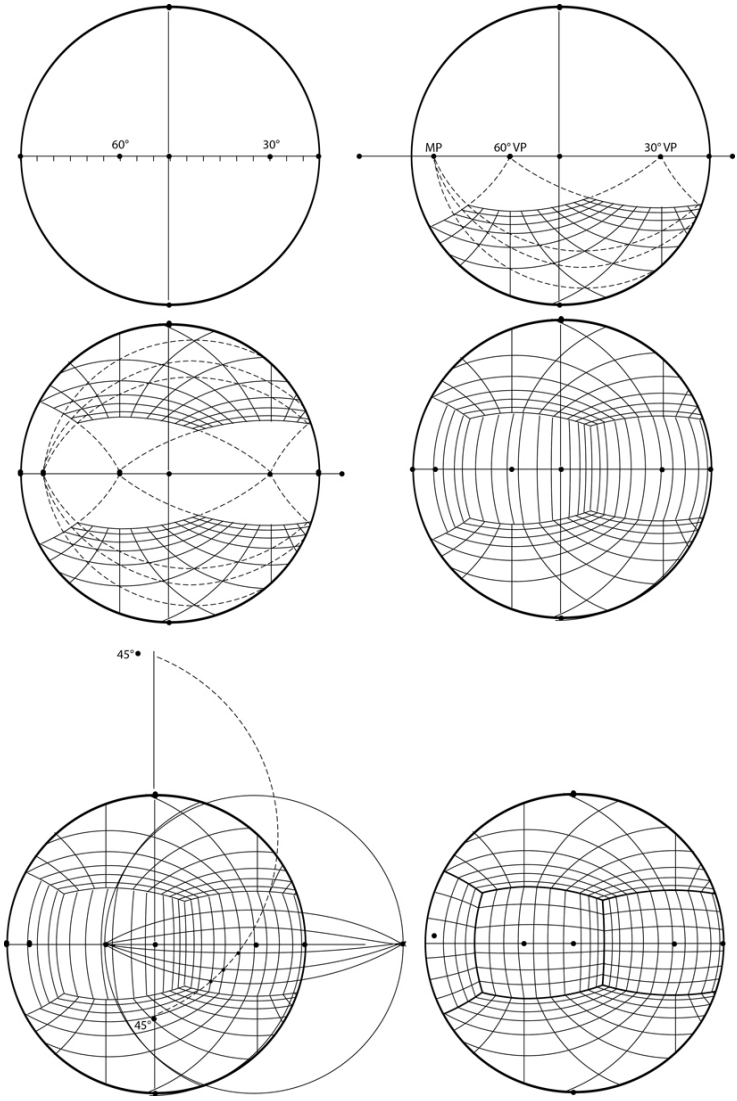


Figure 32.14 A five-point grid turned 60˚/30˚. **Return to text.**
404. 405.

chapter 32
Five-Point Perspective

DOI: 10.4324/9781003488101-44

394. Five-point perspective is a fisheye view, displaying everything from east to west and from north to south. Everything in front of the viewer is depicted. The picture plane is a hemisphere. Horizontal, vertical, and angled lines projected on a hemisphere behave differently than when projected on a cylinder. Before drawing a five-point image, how these lines appear when projected on a sphere must be understood.

Five-Point Perspective Components

Horizontal Lines (*y*-Axis)

A horizontal line of infinite length would connect to vanishing points on the horizon line: one at the extreme left and the other at the extreme right of the sphere. The horizon line, being at the viewer's eye level, is drawn as a straight line. Horizontal lines not aligned with the eye level are curved. The curve is a great circle (Figure 32.1).

Horizontal Lines (*x*-Axis)

Horizontal lines parallel to the line of sight are drawn as a great circle, with one vanishing point at the center of vision and the other directly behind the viewer (Figure 32.2).

Vertical Lines (*z*-Axis)

Vertical lines are drawn as a great circle and have vanishing points at zenith and nadir (Figure 32.3).

Angled Lines

Angled lines have vanishing points at an angle corresponding to the line being drawn. They are also drawn as a great circle (Figure 32.4).

Flattening a Sphere

Now that the theory of how lines appear when projected on a hemisphere is understood, how are they drawn on a flat surface? The paper has only two dimensions; the hemisphere has three. So, before these lines can be plotted on the paper, the hemisphere must first be flattened. Flattening a round surface is a problem that has plagued cartographers for thousands of years. It is a problem that still exists today; it is a problem that cannot be solved. Flattening a spherical surface, without distortion, is impossible. If a ball was cut in half, and then flattened, the only way to accomplish this task would be to tear, stretch, or fold the ball. No matter the approach, the shape of the ball will suffer. A cone or cylinder can be flattened without tearing, folding or stretching. This is called a developable surface. A sphere is not a developable surface. Any flat representation of a sphere will, by its nature, be distorted.

Over the centuries cartographers and mathematicians have found a variety of ways to limit this distortion. There are well over fifty methods to project a curved surface on a flat plane. The methods developed often diminish distortion in one aspect while increasing it in others. Each method leads to different results. Depending on the application, one method is often more advantageous than another.

The best method for drawing purposes is an azimuthal projection. There are many different azimuthal projections; among them are gnomonic, orthographic, stereographic, and equidistant.

Gnomonic Projection

The gnomonic projection is one of the oldest, dating to the sixth century BC. While the center of the image has little distortion, the edges of the sphere are greatly stretched. Additionally, this method cannot display a true 180°. The outside edge of the sphere is at infinity (Figure 32.5).

Orthographic Projection

An orthographic projection puts the station point at infinity. As with gnomonic projection, the orthographic projection is more accurate toward the center of the sphere. But while the gnomonic projection stretches the edges of the sphere, the orthographic projection compresses them. An orthographic projection is like a photograph of the earth from space. The land and water masses are foreshortened as the surface of the sphere recedes and becomes more oblique to the viewer (Figure 32.6).

Stereographic Projection

The stereographic projection places the station point at the far edge of the sphere. The image is still distorted; the projected circumference of the sphere is much too large. But this is closer to the desired result (Figure 32.7).

Azimuthal Equidistant

The azimuthal equidistant projection preserves the circumference of the sphere. In addition, all lines from the center point are straight and have correct angles. There is still noteworthy distortion, as the diameter of the sphere is considerably smaller than the diameter of the projection. For drawing purposes, however, this is the best projection possible (Figure 32.8).

Five-Point Grid

After examining how lines of various orientations look when plotted on a hemisphere, and discussing the best sphere projection possible, combine this information to plot a five-point perspective grid.

Horizontal Lines (*x*-Axis)

Lines parallel to the viewer's line of sight, lines along the *x*-axis, appear as true straight lines receding to the center of vision. To create a series of evenly spaced lines receding in space, first

draw a horizontal line along the ground plane, divide the line into even spaces, and then project each increment to the center of vision (Figure 32.9).

Lines on the *z*- and *y*-Axes

Vertical and horizontal lines on these axes are curved. They are a great circle when drawn on the picture plane but not quite a great circle on the drawing. There is some distortion due to the equidistant projection method. Considering this image is not a developable surfaceâ€”and therefore can never be truly accurateâ€”it saves a great deal of time and effort to simply use a compass arc. The shape of a compass arc is very close to the distorted arch.

Placement of Vertical Lines (*z*-Axis)

Think in terms of degrees when placing vertical lines in specific locations. There are 180° between the left and right vanishing points. Measure angles in degrees, along the horizon line. For example, if using a line 45° to the right, place a dot centered between the right vanishing point and the center of vision (Figure 32.10, left). Vertical lines are drawn with a compass, connecting to the vanishing points at zenith and nadir (Figure 32.10, right).

Placement of Horizontal Lines (*y*-Axis)

Horizontal lines are approached the same as vertical lines. Measure in degrees, above or below the horizon line, to determine their placement. Use a compass to connect to the left and right vanishing points (Figure 32.11).

Create the Grid

Use a 45° vanishing point to create a series of squares (Figure 32.12). Repeat the process to create a grid (Figure 32.13).

Angled Grid

In the previous five-point example, the room's front wall was oriented perpendicular to the line of sight (equivalent to a one-point perspective view). This room can be drawn at any angle by relocating the vanishing points along the horizon line, but the vanishing points must remain 90° apart. For example, to create a grid that is angled 60/30° to the viewer, place a point 60° from the far left vanishing point, and another point 30° from the far right vanishing point (Figure 32.14, top left).

To measure squares, it is helpful to draw 45° angles in perspective. These angles are found from points placed on the horizon line, 45° from the vanishing points (Figure 32.14, top right).

Create a vertical grid by using vertical measuring points (Figure 32.14, bottom left).

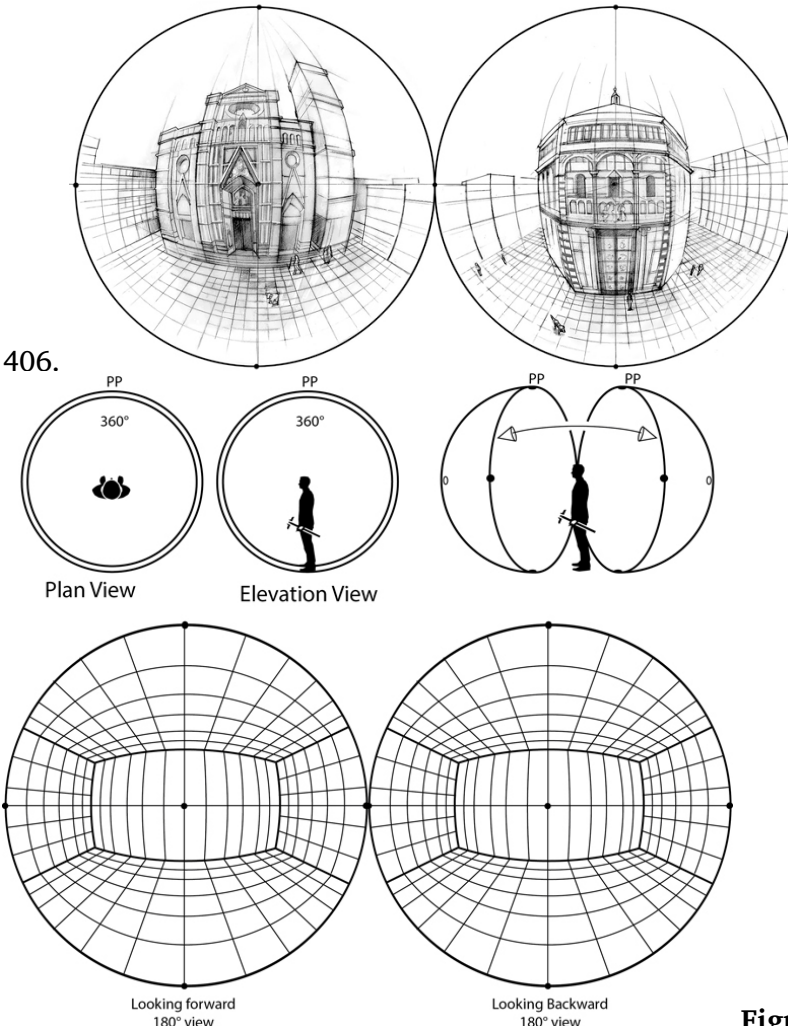


Figure 33.1 Six-point perspective. **Return to text.**⏎ 408.

chapter 33
Six-Point Perspective

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407. Five-point perspective displays 180° of information, but it is only half of the viewer's environment. Six-point perspective adds the other half. A six-point diagram is a full 360° view—everything surrounding the viewer is displayed.

The picture plane is a sphere, cut in half, and opened to show both ends. The viewer sees the two halves. One half displays what is in front of the viewer and the other what is behind. The two halves can be displayed stacked or side by side. There are six vanishing points, one in front of the viewer and one behind, one above the viewer and one below, one to the left of the viewer and one to the right. The two halves share top, bottom, left, and right vanishing points (Figure 33.1).

Creating a six-point grid is the same as a five-point grid, except it is done twice.

409. 410.

part thirteen
Miscellaneous

411. 412.

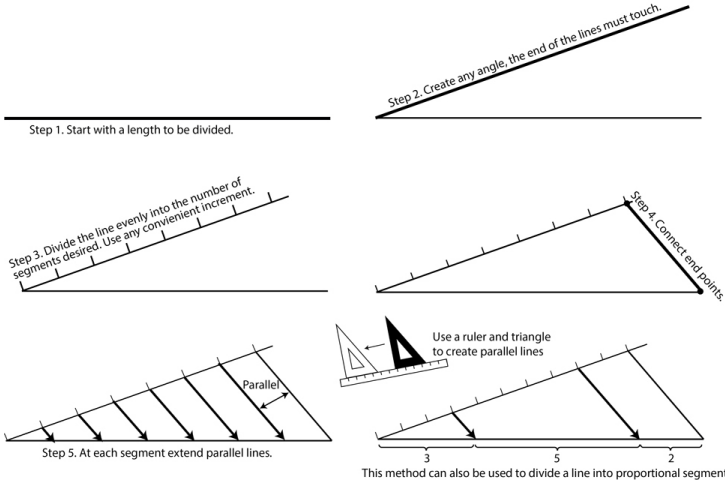

Figure 34.1 Dividing a length into evenly spaced increments.

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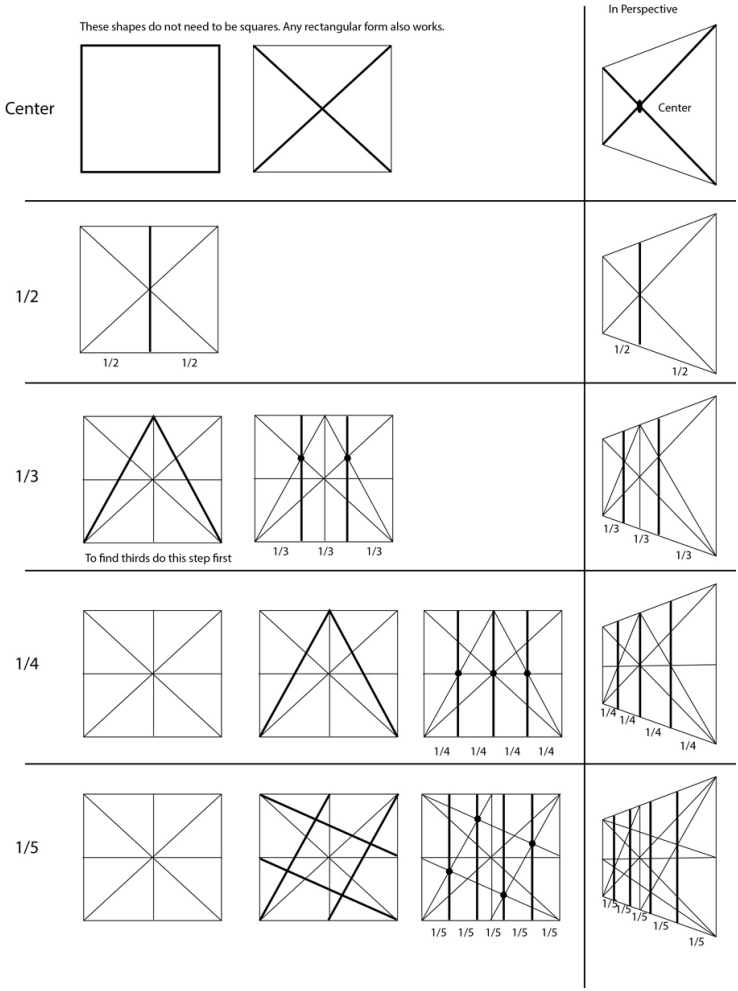


Figure 34.2 Dividing a rectangle or square into evenly spaced increments. **Return to text.**⏎ 413.

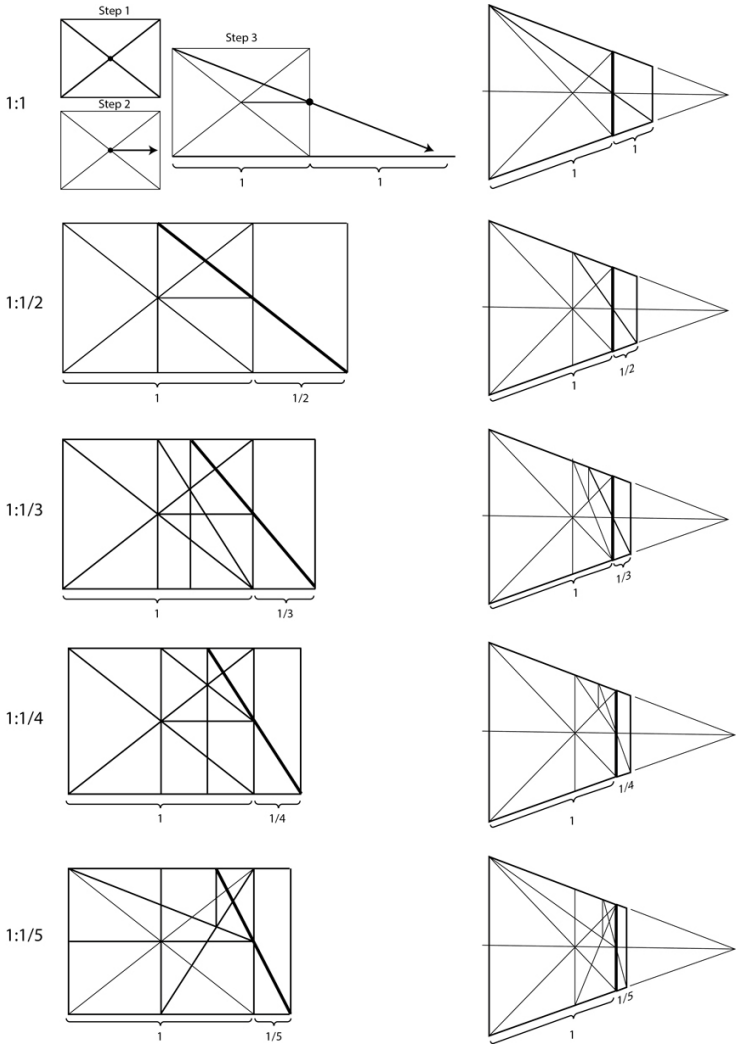
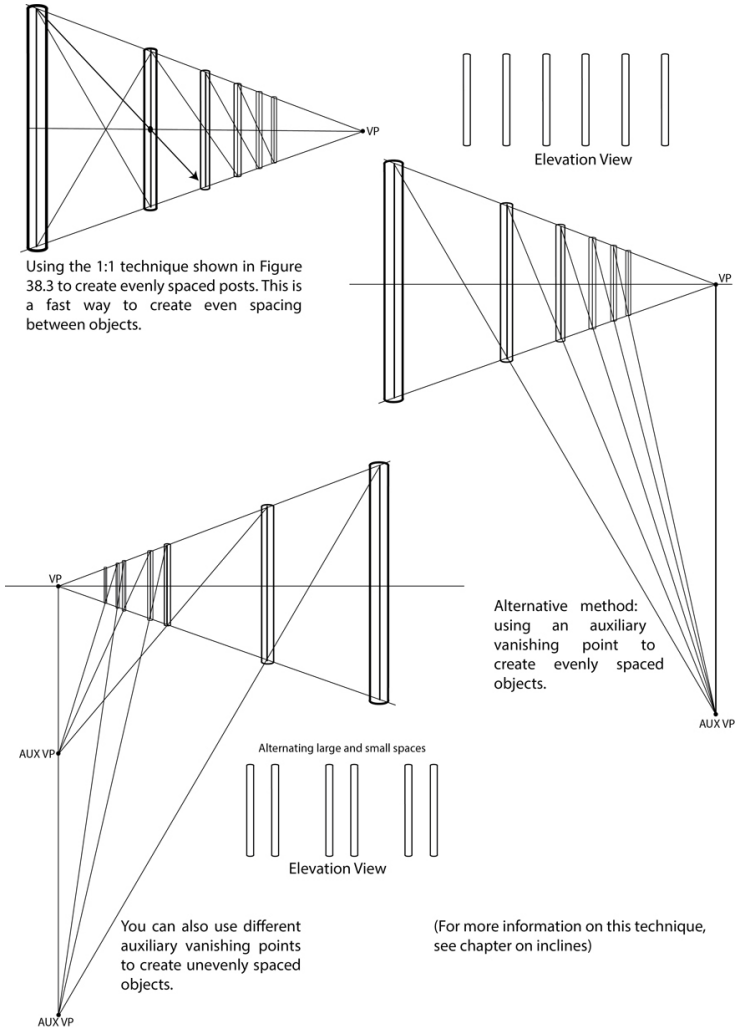


Figure 34.3 Techniques for multiplying distances. Return to text.



414.

Figure 34.4 An auxiliary vanishing point is a useful tool to create evenly spaced divisions. **Return to text.**⏎ 415. 416.

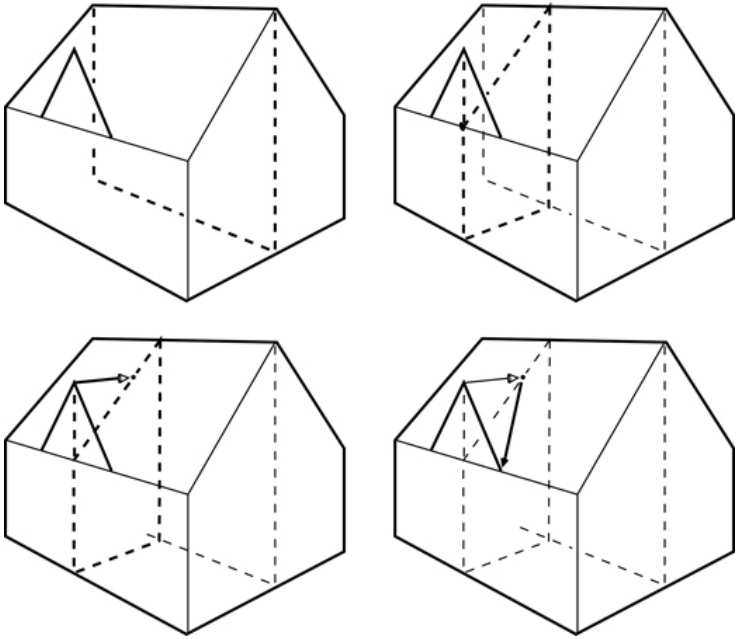


Figure 34.5 Drawing the intersection of a dormer with a roof line. Return to text.⏎

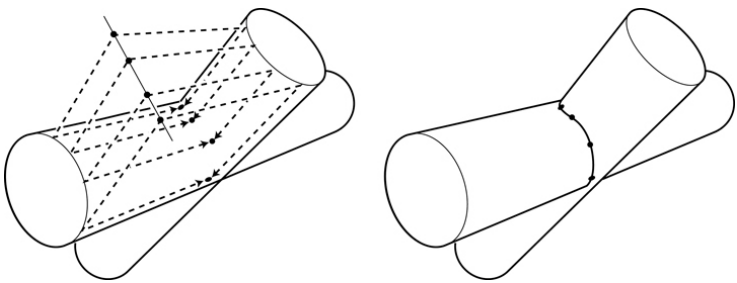


Figure 34.6 Using cross-sections to draw curved intersecting forms. Return to text.⏎ 417.

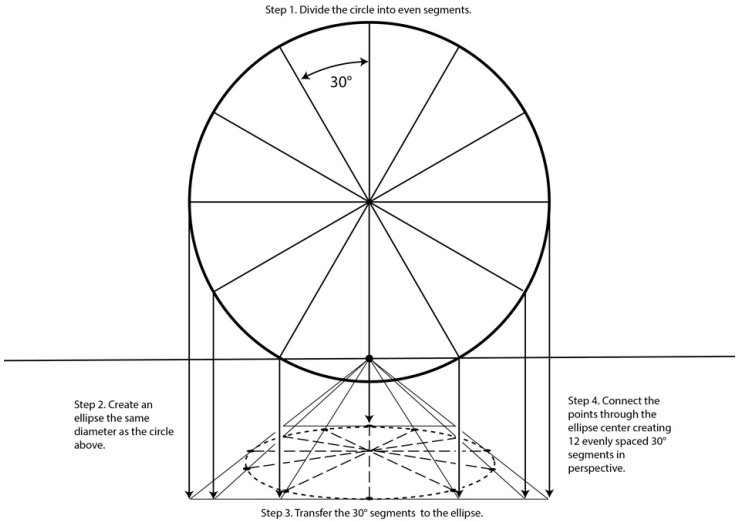


Figure 34.7 Transfer evenly spaced segments from a plan view to an ellipse. **Return to text.**⏎

chapter 34
Miscellaneous

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Dividing Lengths

Dividing a length into a given number of spaces can be done with a ruler and a little math. A better method involves using a ruler and a triangle. It is fast, accurate, and no calculator is needed (Figure 34.1). This technique only works on lines parallel to the picture plane. It does not work on lines that are foreshortened. It is an excellent tool to plot evenly spaced segments.

Another technique (that does work with foreshortened lines) uses a variety of methods to divide squares or rectangles into even segments. There are several methods; each results in a

different number of divisions (Figure 34.2).

Multiplying Lines

If an existing line needs to be made longer by a given percentage, there are a few methods that will assist in this endeavor (Figure 34.3).

Using an auxiliary vanishing point is an alternative method to create evenly spaced segments (Figure 34.4).

Intersecting Forms

The shape created by two intersecting forms can be complex. Dozens of examples can be presented, each looking quite different, but each solved using the same basic method—cross-sections. Cross-sections can be used to find the intersection of one form with another. For example, a dormer is the intersection of one prism with another. To find this intersection, draw two cross-sections. First bisect the roofline at the ridge (Figure 34.5, top left). Then draw another cross-section, at a right angle to the first, along the centerline of the dormer (Figure 34.5, top right). The junction of the dormer's ridgeline to the building's roofline is the intersection of the two shapes (Figure 34.5, bottom left).

Drawing the intersection of two curved shapes (or, for that matter, any two shapes) uses the same method. Drawing more cross-sections creates more intersections and a more accurate shape (Figure 34.6).

Dividing a Circle

Dividing a circle into even segments has many applications (revolving doors, spiral staircases, spoked wheels, etc.).

Decide on the number of segments needed and divide that number by 360. For example, if dividing a circle into twelve even segments, each will be 30° ($360 \div 12 = 30$). Transfer the segments from a plan view to a perspective view (Figure 34.7).

Glossary

Angle of Incidence.
: The angle between the light ray and normal.

Arc.
: A section of the circumference of a circle.

Artificial Light
: Light from a source other than the sun or moon.

Bird's-Eye View
: An image where the viewer is looking down.

Bisect
: Divide into two equal parts.

Center of Vision (CV)
: Where the viewer is looking The focal point.

Chord
: A line segment with endpoints that align on a circle.

Circumference
: The perimeter of a circle.

Cone of Vision
: A 60° cone emanating from the viewer's eye, intersecting the picture plane, creating a circle around

the center of vision Objects drawn outside this circle become noticeably distorted.

Congruent
Having the same angles or measurements.

Converging Light
Shadows resulting from an artificial light source.

Converging Lines
Parallel lines that connect to a single vanishing point.

Cross-Section
The intersection of a three-dimensional form by a plane.

Cube
A prism with six square sides meeting at a right angle.

Cuboid
A rectangular prism with each face meeting at a right angle.

Cylinder
A three-dimensional form with parallel sides and two circular ends.

Diameter
A line that passes through the center of a circle with both ends touching its circumference.

Diminution
The appearance of an object getting smaller as it moves further away from the viewer.

Elevation View
A side view showing height and depth, or a front view showing height and width There is no perspective, no diminution, no foreshortening.

419. Equilateral

All sides of a polygon are the same length.

Eye Level (EL)

The distance from the ground to the viewer's eye The horizon line is always at the viewer's eye level.

Field of Vision

The area that can be seen without the viewer turning their head.

Five-Point Perspective

A 180° view of the world The picture plane is half a hemisphere.

Foreshortening

The apparent reduction in length of an angle due to the position from which it is viewed.

Four-Point Perspective

A panorama view up to 360° The picture plane is a cylinder.

Great Circle

A cross-section of a sphere that creates the largest diameter possible The circle intersects the center of the sphere.

Ground Line (GL)

Generic: A line drawn on the ground plane Shadows: The angle of a shadow cast from a vertical line on a horizontal surface.

Ground Plane

The horizontal surface of the ground.

Hemisphere

Half a sphere.

Horizon Line (HL)
The edge of the earth; the line that separates sky from land.

Hypotenuse
The longest side of a right-angled triangle.

Isosceles Triangle
A triangle where two sides are of equal length.

Linear Perspective
A system using the rules of geometry to depict 3-D space on a 2-D surface.

Light Angle (LA)
The angle of the light ray to the ground plane.

Line of Sight
An imaginary line indicating the direction the viewer is looking.

Major Axis
The longest distance across an ellipse.

Measuring Point (MP)
A point that transfers the distance of a foreshortened line to a line parallel with the picture plane, creating an isosceles triangle.

Minor Axis
The axis through the center of the ellipse, 90° to the elliptical plane.

Natural Light
Light from the sun or moon.

Negative Light
When a natural light source is located behind the viewer.

Normal
A line at right angles to a reflective surface.

Orthogonal Lines
Lines at right angles.

Orthographic.
Representing a three-dimensional form using two-dimensional (plan and elevation) views.

One-Point Perspective
Vertical and horizontal dimensions are parallel to the picture plane Foreshortened lines converge to the center of vision.

420. Parallel Light
When a natural light source is 90° to the line of sight.

Peripheral Vision
The visual area outside the cone of vision.

Perpendicular
Two lines intersecting at 90° angles.

Plane
A flat surface.

Plan View
A top view showing width and depth There is no perspective, no diminution, no foreshortening.

Picture Plane (PP)
A transparent plane between the viewer and the world.

Polygon
A closed plane formed by three or more line segments.

Polyhedron
A solid form with polygon sides.

Positive Light
When a natural light source is in front of the viewer.

Prism
A three-dimensional form with two parallel and congruent bases.

Pythagorean Theorem
The square of the hypotenuse is equal to the sum of the squares of a right-angled triangle's other two sides.

Radius
The distance from the center of a circle to the circumference.

Reference Point (RP)
A point used to move objects forward or backward in space.

Right Angle
A straight line that is 90° at its point of intersection with another straight line.

Six-Point Perspective
A 360° view of the world The picture plane is a sphere.

Sphere
A three-dimensional form where every point of its surface is equal distance from its center.

Station Point (SP)
The viewer's eye.

Two-Point Perspective
Vertical dimensions are parallel with the picture plane Horizontal dimensions are foreshortened and connect to right and left vanishing points.

Three-Point Perspective

No sides of the object are parallel with the picture plane The center of vision is above or below the horizon line.

Vanishing Point (VP)

A point at infinity where objects disappear.

Worm's-Eye View

An image where the viewer is looking up.

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